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STANDARDIZATION OF TERRA COTTA ANCHORAGE: AN
ANALYSIS OF SHOP DRAWINGS FROM THE
NORTHWESTERN TERRA COTTA COMPANY AND THE O.
W. KETCHAM TERRA COTTA WORKS

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A THESIS

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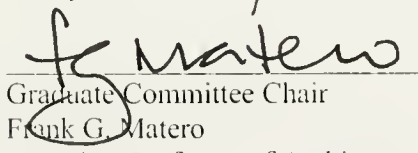
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INTRODUCTION

While the manufacture of terra cotta is traceable to an ancient building practice, its history of success and failure reflects shifts in architectural taste and technology. The emergence of terra cotta as a building material in America was a nineteenth-century phenomenon reflecting innovative building technologies. The transition from load-bearing technology to the skeletal steel frame allowed the American city to grow in density and complexity as larger buildings accommodated increasing populations. This new trend in building technology embraced terra cotta and its complicated metal anchorage systems due to the material's low cost and light weight. The popularity of terra cotta coincided with this building boom resulting in the construction of thousands of terra cotta buildings in American cities.

With new applications of the material, however, came new problems with installation and durability. Over twenty of the terra cotta manufacturers across the nation joined together to create the National Terra Cotta Society (NTCS) in 1911. The purpose of this organization was to promote terra cotta during the construction boom and to enhance its performance by using standardized construction techniques and durability testing. Through an in-depth discussion of terra cotta anchoring systems, this paper will analyze these standards, the reasons for their inception, the success of the recommendations, and their use in common practice.

The standards attempted to demonstrate common practices among the terra cotta manufacturers, inform architects and masons of proper installation techniques, and eliminate faulty construction that accelerated deterioration. How well did the terra cotta

manufacturers adhere to the standards? Were installation methods constantly changing as new trends in building technologies, such as structural concrete, were implemented in construction? To illustrate these ideas, over twenty shop drawings from the Northwestern Terra Cotta Company and the O.W. Ketcham Terra Cotta Works, both NTCS members, were analyzed and compared to the NTCS standards published in 1914 and 1927. The selected drawings from the Northwestern Terra Cotta Company date from 1900 to 1915 and provide context for the earlier set of standards. For the O. W. Ketcham Terra Cotta Works, the selected drawings range from 1926 to 1932 and highlight revisions made to the standards in 1927.

When a building deteriorates, the owner's options are: demolition, cost-effective repair, or restoration. For terra cotta buildings, deterioration often manifests itself as loose blocks due to failed anchorage, which on a skyscraper can be deadly. As a result, the building is usually re-clad with another material –sometimes over the existing terra cotta or sometimes replacing the terra cotta completely –if the building is not demolished altogether. Restoring the anchoring systems is a costly endeavor especially as the antiquated hangers and anchors are no longer used in modern construction practices. A good restoration plan must take into account the engineering capacity of the original builders as well as adapt to the existing anchorage configurations underneath the terra cotta blocks. The uncertainty of the anchorage design in combination with inconsistent adjustments made on-site during original construction indicates that any restoration plan has the potential to repeat mistakes in the past and even accelerate deterioration.

The NTCS standards and manufacturer's shop drawings, when available, can provide indispensable clues for preservationists attempting to restore terra cotta buildings.

Recent preservation efforts have raised awareness of the value of terra cotta's craftsmanship as well as the proliferation of terra cotta buildings across the United States. The purpose of this thesis is to provide an additional tool for the preservation of terra cotta buildings. By detailing installation techniques, how the techniques were developed, and how they were adapted to twenty buildings attributed to the Northwestern Terra Cotta Company and the O. W. Ketcham Terra Cotta Works, this work will shed some light on the forgotten building technology of terra cotta hanging systems.

CHAPTER 1: MATERIAL TECHNOLOGY

HISTORY

“When once the architects of New York began to recognize the use of architectural terra cotta they caused a vast amount of development in the production of it.”¹

—James Taylor, New York Architectural Terra Cotta Company

Terra cotta as a building material has endured many cycles of popularity and decline since its inception in ancient Rome and the ancient Near East. It is defined in its broadest sense as, “both pottery and structural objects made of burned clay and having a porous body. The term architectural terracotta is usually applied to those clay products employed for structural decorative work which cannot be formed by machinery; they are moulded [sic] by hand.”² It is characteristically different from brick in its clay composition and higher firing temperature. After the decline of the Roman Empire, the manufacture of terra cotta was discontinued and forgotten. It was not until the Renaissance in Italy and Germany that terra cotta reemerged as a structural material. At this point, the 14th century artisans revived the material complete with a sophisticated building technology that included the colorful glazing practice of Faience.

Another period of decline ensued from the sixteenth century to the nineteenth century. However, during the industrial age of the nineteenth century in England and Germany, terra cotta regained popularity for its malleability, resistance to pollution, light

¹ James Taylor, “The History of Terra Cotta in New York City,” *Architectural Record* 2 (1892): 144.

² Heinrich Ries, *Building Stones and Clay Products: A Handbook for Architects* (New York: John Wiley and Sons, 1912).

weight, durability, and its low cost.³ In the late nineteenth century, after urban disasters such as the Chicago Fire of 1871, terra cotta was also hailed as a fire-proof material.⁴ Once again, as technology shifted towards the glass skyscraper era in the 1930s, use of architectural terra cotta declined as it was replaced by glass and thin ceramic veneers.⁵ Through preservation efforts, terra cotta is being rediscovered as a quality building material and slowly becoming attractive again as a medium for modern architects.

The earliest history of terra cotta in the United States can be traced to 1849-1851 with the small manufacturers: Boyden & Ball, and Tolman, Luther & Co., both in Worcester, Massachusetts. Simultaneously, New York architects such as Richard Upjohn and James Renwick were experimenting with terra cotta ornament for their buildings.⁶ New Yorkers were skeptical of the material at first and questioned its durability in the harsh American climate.⁷ With quality examples such as Upjohn's Trinity Building and the terra cotta display at the New York Crystal Palace Exhibition of 1853, a handful of terra cotta manufacturers were inspired to open their businesses across the country.⁸

Undoubtedly, these early manufacturers were inspired by the popularity of "Mrs. Coade's Stone" that was imported from England. Created in 1769, Coade's moldable artificial stone was very durable and used to simulate all kinds of materials for ornamental

³ Nancy D. Berryman and Susan M. Tindall, *Terra Cotta* (Chicago: Landmarks Preservation Council of Illinois, 1984), 2.

⁴ Susan Tunick, *Terra-Cotta Skyline : New York's Architectural Ornament*, 1st ed. (New York: Princeton Architectural Press, 1997), 7.

⁵ A. Daniel Barton, Jr., "O. W. Ketcham Terra Cotta: Reflections on an Industry in Chaos after World War Two," *APT Bulletin* 32, no. 4 (2001): 15.

⁶ Susan McDaniel Ceccacci, "Architectural Terra Cotta in the United States before 1870" (Master of Art, Boston University, 1991), 23-24.

⁷ Taylor, "The History of Terra Cotta in New York City," 138.

⁸ Ceccacci, "Architectural Terra Cotta in the United States before 1870", 30-40. Ceccacci, 30-40

details and architectural elements such as capitals, keystones, and chimneypieces. Mrs. Coade's Stone was mass produced and sold through a catalog. As it gained popularity in England, Americans began to import the material to adorn their own homes. William Thornton's Octagon House (1800) in Washington, DC, has remaining examples of this artificial stone marked "Coade London, 1799."⁹

While terracotta was being produced in America before the 1870s, it was the Chicago Terra Cotta Works (founded in 1868) that spearheaded the rise in terra cotta manufacture. By 1870, the company's superintendent was Englishman James Taylor who was educated in the British Coade stone tradition as well as the practices of that country's successful Blashford Terra Cotta Works. As Michael Stratton notes in *Terra Cotta Revival*, Taylor, "saw the future in terms of supplying not just vases and window heads but whole facades. He distributed a circular emphasizing the capabilities of the works declaring that the material would be supplied to any required design."¹⁰ Indeed, after the Chicago Fire of 1871, architects like William Le Baron Jenney commissioned the Chicago Terra Cotta Company to manufacture the fire proof material for their buildings.¹¹

Taylor is also credited with making the distinction between "terra cotta" and "architectural terra cotta." The former was considered, "fired clay that imitated other building materials...that could be lacquered, painted, or covered with colors to represent any material."¹² The latter referred to a "fired clay that declared its distinctly clay-like

⁹ Ibid., 11-13.

¹⁰ Michael Stratton, *The Terracotta Revival* (London: Victor Gollancz, 1993), 148.

¹¹ Ibid.

¹² Tunick, *Terra-Cotta Skyline : New York's Architectural Ornament*, 15.

properties... [and] that the finish be that of natural clay.”¹³ This discussion of the true character of the material mimics John Ruskin’s aesthetic philosophy outlined in his 1849 treatise, *The Seven Lamps of Architecture*. In his chapter on the Lamp of Truth, he states, “But in Architecture another and a less subtle, more contemptible, violation of truth is possible; a direct of falsity of assertion respecting the nature of material, or the quantity of labor. And this is, in the full sense of the word, wrong.”¹⁴ With Ruskin’s influence, it was commonly held in the mid-nineteenth century that, “all materials are good, when used honestly, each for the purpose to which it is best adapted, and bad when used for purposes to which it is not adapted, or to counterfeit some other material.”¹⁵ But in the twentieth century, ironically, terra cotta production peaked precisely because it was a cheap imitation of stone; and, as the material lost its “distinctness” as hailed by Taylor, it was forgotten when the cheaper imitation stone became available in the form of concrete.

In the early stages of use in America, the characteristic hue of terra cotta was a rich red that resulted from the type of clay used and the firing temperatures. By 1890, other clay deposits were discovered and terra cotta was manufactured in yellow and buff colors in addition to red. This range of colors meant that terra cotta could be used to imitate a variety of stones such as brownstone or limestone. Often “slips” were applied to the terra cotta body to even out the tone of the fired material. Slips are made from the same clay body as the terra cotta pieces but are applied in a creamy state over the dried material before firing. By 1894, salt glazes were introduced as another way to manipulate the color

¹³ Ibid.

¹⁴ John Ruskin, *The Seven Lamps of Architecture* (New York: Dover Publications, 1880,1989).

¹⁵ Sanford E. Loring and William Le Baron Jenney, *Principles and Practice of Architecture* (Chicago: Cobb, Pritchard, & Co., 1869), 36.

of the terra cotta pieces. Robert C. Mack states, "In this glazed form, terra cotta became one of the most popular building materials for exterior surfaces of buildings until its decline in the 1930's." These glazes were available in a number of colors and created a glassy surface when fired.¹⁶ New applications of the material, technological advances, and aesthetic trends shaped the industry of terra cotta throughout the history of its manufacture in the United States.

MANUFACTURING PROCESS

"A fine fire-clay free from lime or iron deposits, is moulded or carved into the desired form, allowed to dry in rooms heated for the purpose, and there burnt in air-tight kilns. While in the kilns 30-40 hours, it is subjected to a heat sufficient to melt steel."¹⁷

—Sanford E. Loring

The terra cotta factory is divided into various departments: clay preparation, drafting, modeling, molding, pressing, finishing, drying, glazing, firing, fitting and numbering, shipping and handling, and installation. Once the architect specified terra cotta for a building, elevation drawings were created at 1/4" - 1/8" scale indicating where the material would be employed. The terra cotta manufacturers used these drawings to produce a competitive bid for the project. After the manufacturer was selected, the architect re-drafted the elevations at a larger scale (1/2" or 1") and sometimes included full

¹⁶ Robert C. Mack, "The Manufacture and Use of Architectural Terra Cotta in the United States," in *The Technology of Historic American Buildings: Studies of the Materials, Processes, and the Mechanisms of Building Construction*, ed. Edward Jandl (Washington, DC: Foundation for Preservation Technology, 1983), 119.

¹⁷ Loring and Jenney, *Principles and Practice of Architecture*, 35.

size details. When utilizing terra cotta in a building, the specifications had primary importance over other steps of construction since manufacturers required at least eight weeks for production.¹⁸



Figure 1: Drafting room at the Northwestern Terra Cotta Company. Photocopied image found in the vertical files of the Northwestern Collection at the National Building Museum.

The manufacturer then prepared new “shop drawings” at the same scale to “determine joint locations and to lie out a numbering pattern which later could serve as a ‘setting plan’ to show the masons the correct placement for each block.”¹⁹ The manufacturer relied on his expertise at this stage to design the strongest blocks to fit the

¹⁸ Michael Stratton, “The Terra Cotta Industry: Its Distribution, Manufacturing Processes, and Products,” *Industrial Archaeology Review* 8, no. 2 (1986): 206.

¹⁹ Mack, “The Manufacture and Use of Architectural Terra Cotta in the United States,” 128.

building's structure as well as to conceal joints for aesthetic purposes. The drawings required, "years of practical experience in the manufacture of terra cotta, knowledge of the manufacturing methods of the factory in which the material is to be made, and intimate knowledge of the characteristics of that factory's product, as well as thorough experience in construction and drafting."²⁰ The block details included anchorage points for ties as well as steel members. In addition, the manufacturer drafted an "iron schedule" detailing required anchors, angles, straps, and clamps to secure the pieces to the building frame. Another step in the drafting process included "shrinkage scale" drawings scaled at 13" to the 1' for details to ensure the modelers compensated for the 1/8" to 1/4" shrinkage due to the loss of water in the firing process. All of these drawings were submitted to the architect for final approval.

Each project is designed with terra cotta blocks that are "made for each job individually and with reference to the structural conditions to be met thereon."²¹ To create the blocks, a new batch of clay must be prepared to compensate for desired strength, plasticity and color. The unique chemical identity of a specific clay bed influences the final product. In order to stabilize the quarried material, the clay was allowed to weather which helped to break down the raw material, increase its plasticity, and reduce the chemical changes of the terra cotta after firing.²² Then the raw clay was processed through a mill to loosen any impurities, such as stone or metal scraps, and crush the material into a consistent powder. The clay was next cleaned to remove the impurities from the mix.

²⁰ Edward Putnam, "Architectural Terra Cotta: Its Physical and Structural Properties," *The Brickbuilder* (1911): 29.

²¹ William Lockhardt, "Architectural Terra Cotta," *General Building Contractor* (1931).

²² W.A. McIntyre, *Investigations into the Durability of Architectural Terra Cotta and Faience*. Building Research Station Special Report, No. 12 (London: Building Research Station, 1929), 6.

Originally, this process required a slurry of water to transform the clay into a creamy slip allowing foreign particles to settle out. Eventually, the process was streamlined with machines that could eliminate the impurities while keeping the clay in a workable state.

Just as the final drawings had to compensate for shrinkage, so did the mixing process. To reduce shrinkage, a sufficient amount of grog was added to the clay. Grog is the, “ground up pieces of burned clay or brick”²³ which “retains the same size when heated” and can “resist changes in temperature.”²⁴ Rough measurements of grog and clay were blended and then treated with barium carbonate to prevent the formation of surface scum caused by soluble salts.²⁵ The grog was thoroughly mixed into the clay through a pug mill which eventually extruded stiff clay that could be divided into manageable chunks. Any excess water would have been driven off either with heat or with a sieve. At this point, the clay was ready for ageing which was often called “souring.” For about 12 months the clay body was placed in a cool, dark place that promoted the growth of bacteria which integrated into the material and increased its plasticity.

²³ Ries, *Building Stones and Clay Products: A Handbook for Architects*.

²⁴ Emile Bourry and A. B. Searle, *A Treatise on Structural Ceramic Industries: A Complete Manual for Pottery, Tile, and Brick Manufacturers* (London: Scott Greenwood and Son, 1919).

²⁵ McIntyre, *Investigations into the Durability of Architectural Terra Cotta and Faience*. Building Research Station Special Report, No. 12, 7.

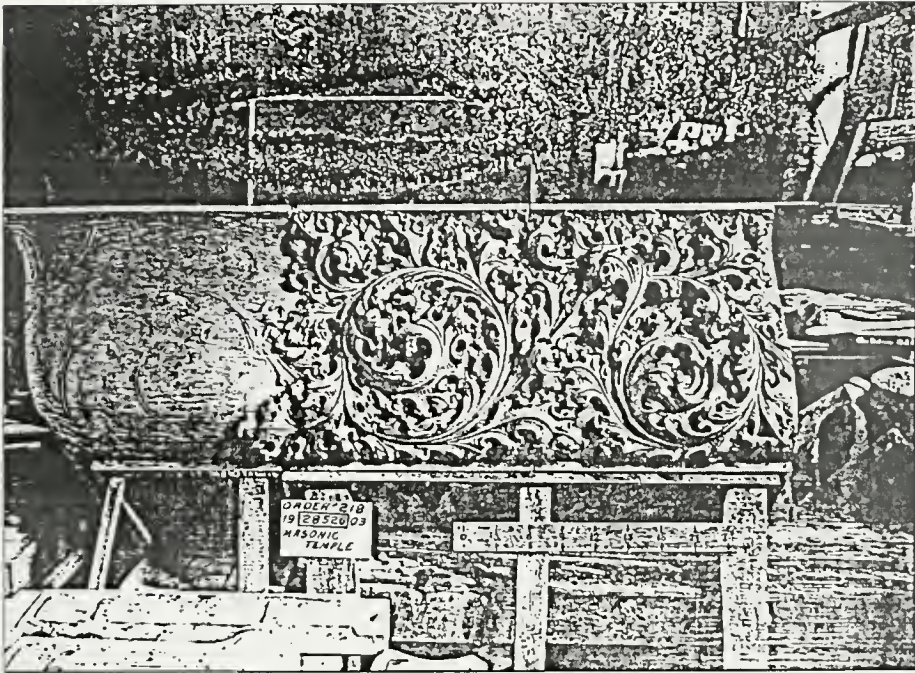


Figure 2: This is an example of some of the intricate detailing sculpted into the blocks. Image found in the vertical files of the Northwestern Collection at the National Building Museum. 1903.

Before the aged clay body is transformed into blocks, plaster models were sculpted according to the specifications of the architect using the “shrinkage scale.” Often, the blocks were made slightly larger on the face than required to provide “lugs” for cosmetic adjustments of the final product during the fitting phase. Larger elements were sculpted as a whole and then cut into manageable sized blocks with attention to joint location. Projecting ornamentation was often molded with clay and attached to the plaster model. After final approval from the architect, plaster of Paris molds were taken from the models. The sectional molds interlocked to ensure accuracy while the multiple sections could be disassembled without disturbing the fragile detail of the block when finished. Beyond the interlocking nodules, each mold was reinforced with steel rods and bound with iron straps.

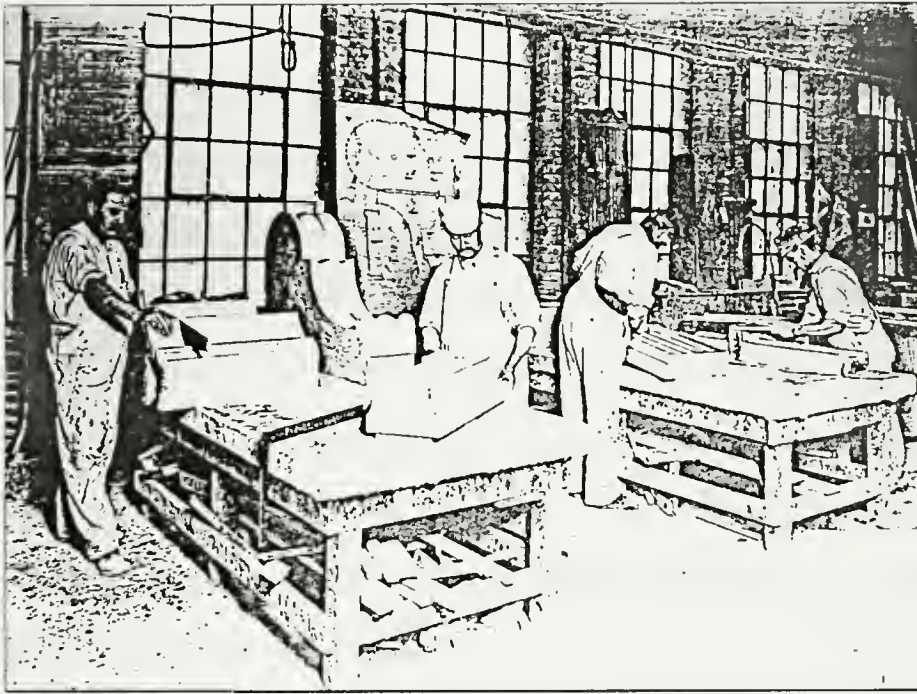


Figure 3: This image illustrates the cosmetic adjustments made to the blocks after molding. Image found in the vertical files of the Northwestern Collection at the National Building Museum.

Once the molds were prepared, blocks of the aged clay were cut into slabs. The presser, after kneading the material to remove any trapped air, forced the smoothed clay body into the mold. After a few hours in the mold, the material stiffened allowing safe removal of the mold sections. As the piece dried, the clay shrunk away from the mold. The hygroscopic plaster of Paris absorbed water out of the clay body causing the surface of the block to condense. When the block was fired in the kiln, this outer layer sintered into the protective fire skin that made terra cotta so durable.

Before the molded pieces were sent to the kiln they must first undergo the finishing process, be allowed to dry completely, and then glazed. The finishing process included rubbing the surface smooth, removing seams, and tooling the surface for a decorative

finish. Each piece also had to be stabilized for installation. This included cutting holes for anchors, scooping out the backing to lighten the material, and scoring grooves on the sides to allow for better mortar adhesion. To strengthen the block, webs of clay would be inserted on the back at six inch intervals following the contours of the piece.²⁶ Once prepared, the pieces would be taken to the drying room which was usually fitted with steam heating. During this process, the manufacturers had to take extra precaution to prevent cracking and warping due to uneven shrinkage. This occurred when the exterior surface of the terra cotta dried faster than the interior. Sometimes this was prevented in a two step drying process using dry heat and then steam heat; at other times the pieces were wrapped with moist cloths to promote even desiccation.



Figure 4: This image shows the terra cotta blocks being sprayed with glaze. Image found in the Ketcham Collection at the Athenaeum of Philadelphia.

²⁶ National Terra Cotta Society, *Architectural Terra Cotta: Standard Construction* (New York: National Terra Cotta Society, 1914).

The last step before the pieces were baked involved the application of the glazes. The two most common types of glazes included a “slip” and a “salt glaze.” The “slip” glaze was popular before the 1890s and consisted of fluid creamy clay that could be brushed or sprayed on the surface of the blocks. This was often done to smooth out the color tone of the piece and to weatherproof it by sealing any pores. The colors of slips were limited whereas the color palette of the “salt glazes” varied widely. The “salt glaze” consisted of mineral oxides including lead and could produce a glassy surface. The popularity of terra cotta as a building material can be directly related to its glazes which increased the architect’s color palette and also duplicated costlier masonry materials like carved granite.

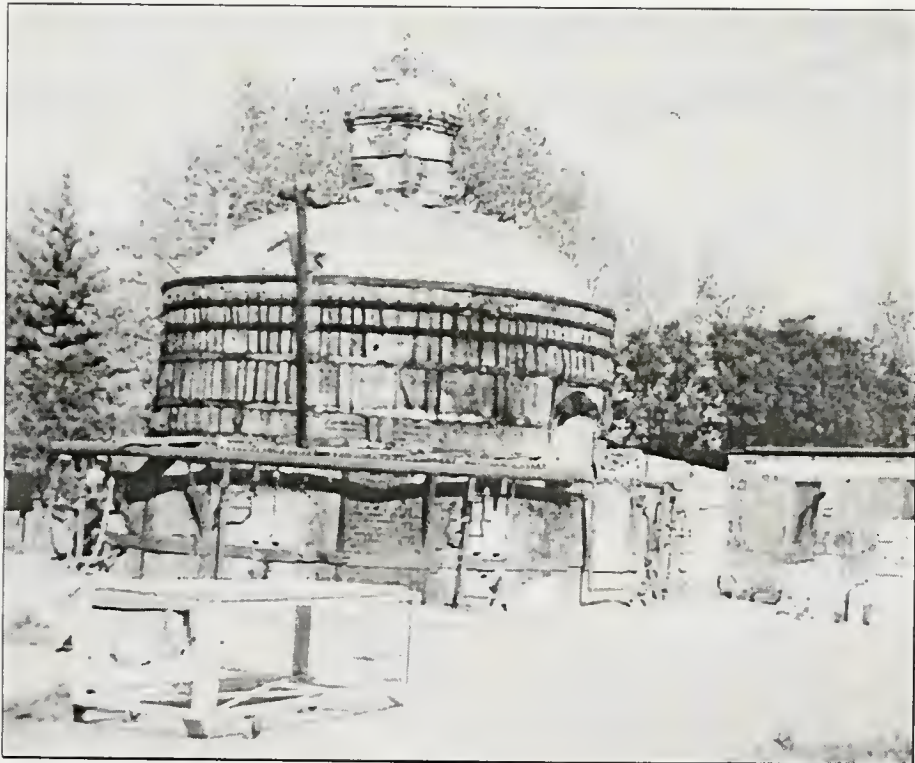


Figure 5: A muffle kiln at the Crum Lynne Factory of the O. W. Ketcham Terra Cotta Works. Image found in the Ketcham Collection at the Athenaeum of Philadelphia.

Firing the blocks in kilns transformed the carefully mixed and decorated clay ware into actual terra cotta. At about 450 degrees, the clay began to sinter.²⁷ Sintering is defined as, “the sticking together of particles when heated to high temperature to form an agglomerated mass, usually of greater density than the starting material. Complex processes of chemical reaction, densification and consolidation take place, but without substantial melting.”²⁸ Muffle kilns and down-draught kilns were the most popular forms used to bake terra cotta. The muffle kiln had a conical shape and a brick lining that separated the terra cotta from a direct heat source thus preventing discoloration. The down-draught kiln was designed with a cavity wall that allowed the heat to spread around, in the middle of, and underneath the structure.²⁹ By radiating the heat throughout the kiln, the pieces were more evenly baked. Over the course of eight to fourteen days the temperature was controlled to make sure the blocks went through “the sweat” to evaporate any excess water, “oxidation” to release any trapped gases, then “main shrinkage” to sinter the material together. The kilns reached temperatures up to 2000 to 2500 degrees and were closely monitored by the manufacturer.

²⁷ Ibid.

²⁸ W. D. Kingrey and Pamela Vendever, *Ceramics Masterpieces: Art, Structure, and Technology* (New York: Free Press, 1986).

²⁹ Stratton, "The Terra Cotta Industry: Its Distribution, Manufacturing Processes, and Products," 210.



Figure 6: This photo shows terra cotta blocks being arranged in sequence and numbered to ensure proper installation on-site. Image found in the Ketcham Collection at the Athenaeum of Philadelphia.

Once the unique terra cotta blocks were manufactured, the factory had to ensure the materials would fit together when installed on the building as specified by the shop drawings. Each section of the elevation was laid out in the factory, customized, and numbered according to the setting plan. Numbering was an attempt to manage the placement of each piece at the site to avoid a complicated sorting process and costly human error. As Edward Putnam states in his article from *The Brickbuilder*, “here is a material carefully made by hand, perhaps rich with expensive modeling and executed in a number of colors, and it is frequently thrown into a cart and actually dumped upon the ground as if it were common brick!”³⁰ It took approximately three weeks to make replacements parts

³⁰ Putnam, “Architectural Terra Cotta: Its Physical and Structural Properties,” 33.

and few extra pieces were made during original production due to the time and man-power required to complete a cycle of the finished product. As a result, extra care was taken to ensure the blocks were not broken during shipping. The manufacturer wedged courses of the blocks into train boxcars using straw packing. Each block was then stacked at the site in reverse order of installation to reduce sorting, breakage, and human error.

In the nineteenth century, the terra cotta manufactures, especially in the mid-west, employed their own masons to install the terra cotta onto the building. By 1901, however, “terra cotta setting was becoming a building specialty and subcontractors did most of the setting.”³¹ The blocks, filled with mortar, were attached to the load bearing structure with hooks that embedded into the mortar. Each piece was held in place until the mortar set and the hooks reinforced the block. With the advent of the steel skeletal frame, installing terra cotta required a complex system of ties, anchors, straps, and clamps. Once the elevations were erected, the surfaces of the terra cotta pieces were cleaned and the terra cotta portion of the building was complete.

TECHNOLOGY SHIFT

In modern times the creator of the skyscraper –the progressive American architect –working with the responsive and enterprising manufacturer, re-discovered, improved, and gave an appreciative public this most durable and versatile of all building materials.

-Fritz Wagner, President of the National Terra Cotta Society, 1914.³²

Lightweight, fireproof, and economical: these characteristics of terra cotta catapulted the material into a pivotal role for the advancement of building technology. The

³¹ Mack, "The Manufacture and Use of Architectural Terra Cotta in the United States," 137.

³² Society, *Architectural Terra Cotta: Standard Construction*, Foreword.

transition from load bearing structures to skeletal construction from the 1840s to the 1890s in Chicago and New York led designers to rely on terra cotta as a cladding as a lightweight material for architectural expression. In the age of disastrous urban fires, terra cotta was promoted as a fireproof material used to protect the structural frames. The technological advancement of the steel frame transformed the terra cotta industry as it adapted to meet the needs of curtain wall construction. Consequently, the manufacture, delivery, and installation of this material proved to be more cost-effective than masonry and highly desirable. In order to understand the broader themes of standardization and anchoring technology, it is important to examine the evolution of terra cotta in relation to building trends of the time.

Like terra cotta, iron has been used in building construction since antiquity. Yet, its use as the primary structural material is a fairly recent phenomenon. In the beginning, iron was hand-wrought and applied to masonry buildings for extra support. Cast iron was invented by the middle ages but it was not widely used until the late eighteenth century. Popularized by English engineer John Smeaton, cast iron was first used for structural members in England's St. Anne's Church (Liverpool, 1772) and the Calico Mill (Derby, 1792). These buildings set precedents for architects experimenting with design themes such as increased light, fireproofing, and open space. Such themes required lighter wall construction that could withstand greater open spans.³³

In America, William Strickland was the first architect to employ cast iron elements in his buildings. In Philadelphia, for example, his United States Bank (1818-24) contained

³³ Carl W. Condit, *American Building Art: The Nineteenth Century* (New York: Oxford University Press, 1960), 25-26.

iron rods to reinforce the arched openings while he used cast iron columns in the Chestnut Theater (1820-22; demolished) and United States Naval Home (1826-33). In New York City, iron manufacturers Daniel Badger and James Bogardus are credited with the advent of iron frame construction in the 1840s and 1850s. While Badger was influential in promoting iron, Bogardus was pivotal in designing construction techniques for iron framing systems. Badger declared iron should be used above all other materials because of its:

strength, lightness and openness of structure, facility of construction, architectural beauty, economy, durability, incombustibility, and ease of renovation and restoration... it had no competitor for a wide range of utilitarian structures, such as stores, office buildings, factories, warehouses, arsenals, and ornamental details.³⁴

Bogardus put this material to the test by creating a cast-iron frame consisting of columns with flanged ends that were bolted to sills at their joints and bolted to spandrel girders through the end flanges. These columns would in turn support another story of sills, girders, and columns and could continue for a number of stories as illustrated in his four-story factory building in New York (1848-48; demolished).³⁵ Buildings could become more spacious, allow for more light, and be constructed quickly.

Even with Bogardus' advancements, the construction industry did not immediately accept the idea of an exclusively cast iron system. By the 1880s, most buildings were constructed with cast iron columns but still relied on timber framing and load-bearing masonry walls. The metal frames of this "cage" construction supported the floors but

³⁴ Ibid., 30-31.

³⁵ Ibid., 33-34.

relied on self-supporting walls.³⁶ It was not until William Le Baron Jenney's eleven-story Home Life Insurance Building in Chicago that the transition to skeletal construction was initiated. This building employed square cast iron columns that were inset into brick piers connected by cast iron lintels. Wrought iron beams and girders were bolted to the columns and pocketed into the brick party walls for extra load support. Above the sixth floor, Bessamer Steel beams were installed as a stronger substitute for wrought iron. This was the first introduction of steel into American framing technology.

After careful investigation, it was determined that Le Baron's building truly exhibited skeletal construction with, "bolted connections, cast iron columns and lintels. wrought iron beams up to the sixth floor, and steel above...with brick piers that carried none of the load of the iron."³⁷ By the 1890s steel skeletal construction is widely adopted in both Chicago and New York. With the steel frame supporting the load of the building, the exterior cladding is tied to the frame but only carries its own weight and wind loads. In the Guaranty Building (Buffalo, 1896), Louis Sullivan, "emphasizes rather than denies the role of the wall-surface, supplanted in its structural role by the steel skeleton, by creating a taut skin of decorative terra cotta."³⁸ The role of the exterior wall changes from serving a structural function to being a palette for design and ornamentation.

Leading to and influencing the transition to skeletal frame buildings were a number of urban disasters including earthquakes and fires. The Chicago Fire of 1871 destroyed 18,000 buildings in a four-mile long area resulting in 100,000 homeless and a loss of \$200

³⁶ Susan Tunick, "The Evolution of Terra Cotta: Glazing New Trails," *APT Bulletin* 32, no. 4 (2001): 4.

³⁷ Condit, *American Building Art: The Nineteenth Century*, 53-54.

³⁸ Stratton, *The Terracotta Revival*, 180.

million worth of property.³⁹ The Boston Fire of 1872 was less devastating but it wiped out over 775 buildings in the central business district.⁴⁰ The 1906 earthquake and subsequent fire struck havoc on San Francisco. The fire spread over 4.7 miles destroying \$250 million dollars worth of property.⁴¹ Even before these disasters it was known, “that iron was incombustible but not fireproof.” Stratton explains:

A fierce fire would cause exposed tie-rods to expand and columns to crack, if they had not already been destroyed by the heat of the flames. Extreme heat would result in the metal melting, while a sudden drop in temperature produced by jets of water could result in cracking and collapse. It was soon appreciated that structural ironwork was best protected by being encased in ceramic, cement, or concrete.⁴²

In the aftermath of such disasters, some pieces of terra cotta still clung to the structural ruins. Soon terra cotta was being used to encase iron joists, to clad cast-iron columns, and to construct interior partitions.

Ironically, in 1871, Chicago builders were attempting fireproof construction with techniques such as one-inch thick concrete layers on top of beams, brick floor arches spanning the joists, and one-inch thick plaster ceilings. In order to prevent the collapse of cast iron columns, John B. Cornell patented (1860), “a column consisting of two cast iron tubes, one inside the other, the space between filled with fire-resistant clay.”⁴³ To protect floor beams, Balthasar Kreischer patented (1871) the technique of cladding the beams with tile. However, it was the use of fireproof, porous terra cotta tile that gave builders the

³⁹ *Chicago Fire 1871* ([cited 1/29/ 2003]); available from www.chicagohs.org/fire/ruin/index/html.

⁴⁰ *Boston Fire 1871* ([cited 1/30/ 2003]); available from www.fire-police-ems.com/books/bg3730.htm.

⁴¹ *San Francisco Fire 1906* ([cited 1/30 2003]); available from americahurrah.com/sanfrancisco/municipalreports/1906/index.htm.

⁴² Stratton, *The Terracotta Revival*, 19.

⁴³ Condit, *American Building Art: The Nineteenth Century*, 44.

confidence to construct with iron. Terra cotta fireproof tile was first patented by George H. Johnson in 1872 but it was Peter B. Wight who promoted the new porous material as a better alternative to the traditional denser variety in 1874.⁴⁴ Terra cotta “lumber” as it was called was infused with sawdust which burned off during the firing process. This resulted in a, “lightweight block which could be sawed, nailed, screwed or otherwise worked like wood.”⁴⁵ It was understood that the, “best practice for fireproofing involved the creation of an impregnable armor against flames and heat. Column casings had to be able to withstand high temperatures for some hours and to be of low heat conductivity.”⁴⁶ The tile could be installed as hollow-tile arches between floor joists, as cladding for cast iron columns, and as masonry blocks for interior partitions.⁴⁷

The shift in building technology to the skeletal frame yielded major profits for investors especially as buildings reached new heights and the population density increased. Terra cotta fit into the budgets of these investors as it reduced manufacture and installation costs within a relatively quick construction period. While each building required a unique set of terra cotta pieces from the manufacturer, the use of molds for original and repeated elements was significantly cheaper than carving each piece from stone. The light weight of the material also resulted in cheaper shipping costs and on-site handling.

From the 1880s to the 1930s the terra cotta industry had to adapt its installation methods from load-bearing masonry to the skeletal frame. Eckardt Eskesen, then president

⁴⁴ Stratton, *The Terracotta Revival*, 149-50.

⁴⁵ Mack, "The Manufacture and Use of Architectural Terra Cotta in the United States," 120.

⁴⁶ Stratton, *The Terracotta Revival*, 166.

⁴⁷ Ibid.

of the Kansas City Terra Cotta and Faience Co., and treasurer of the National Terra Cotta Society, wrote in 1924:

with the introduction of the skyscraper and the concrete building, came before us the problem of how to adapt our material to the changed conditions; how to support a load of terra cotta, which now under the changed conditions, is used simply as a veneer on the front of the building, and how to hang the projecting courses, and tie down the tiers of ashlar work.⁴⁸

New issues that needed to be addressed for this new construction included changes in anchor hardware, assessment of water-tight construction, compression strength assessments, and glaze compatibility. The National Terra Cotta Society published standards of construction to illustrate proper methods to deal with these issues and disseminated them to all members.

RISE AND FALL

“The dream of the modern architect is to build houses entirely out of metal, glass, and cement...In this construction, brick, tile, or terra cotta has no place”

-E.V. Eskesen, President of the Federal Seaboard Terra Cotta Co.⁴⁹

By the 1930s and 40s, American architecture streamlined designs to express the verticality of the skyscraper. With the introduction of the International Style through architects like Mies van der Rohe, traditional terra cotta ornament had no place on the clean, sleek buildings. Conventional construction was replaced with steel and concrete with an aesthetic that represented the machine age. The intricate craftsmanship and time-

⁴⁸ E.V. Eskesen, "The Investigation of Terra Cotta Work at the Bureau of Standards," *ACS Journal* 4 (1924): 159.

⁴⁹ E.V. Eskesen, "Presidential Address for the Thirty-Fourth Annual Meeting of the American Ceramic Society," *Journal of the American Ceramic Society* 15 (1932): 81.

intensive production of terra cotta did not fit into this aesthetic. Changing architectural tastes in combination with the onset of the Depression in the 1930s caused a sharp decline in the demand for architectural terra cotta. In fact, between 1925 and 1935 the volume of sales for the industry dropped 93 percent.⁵⁰

In order to remain in business, many manufacturers tried to promote a variety of alternative products including bathtubs, caskets, and even golf tees.⁵¹ One such product called ceramic veneer, an extruded form of terra cotta facing, revived the industry at first but then drove demand into a steeper decline.

The manufacture of ceramic veneer took full advantage of the machine to mass produce thin slabs of a clay material. The process extruded under high pressure a mixture of clay and water through preset dies producing a flat surface on the front and grooved surface on the back. When dry, the slab was machine-planed smooth, glazed, then fired. This new material was stronger than traditional terra cotta and could be divided into larger units without fear of warping.⁵² The units, ranging in thickness from 1 1/4" to 1", were either applied to the wall with a simple anchoring system of metal ties or directly adhered to the building with mortar.⁵³ Ceramic Veneer was promoted heavily on the west coast as earthquake proof and soon all hand-molded pieces were phased out the catalogs.⁵⁴ By

⁵⁰ Susan Tindall, "How to Prepare Project Specific Terra Cotta Specifications," *APT Bulletin* XXI, no. 1 (1989): 29.

⁵¹ Tunick, *Terra-Cotta Skyline : New York's Architectural Ornament*, 111.

⁵² Robert E. Meadows, *Historic Building Facades: A Manual for Inspection and Rehabilitation* (New York: New York Landmarks Conservancy, 1986), 27.

⁵³ Tindall, "How to Prepare Project Specific Terra Cotta Specifications," 29.

⁵⁴ Barton, "O. W. Ketcham Terra Cotta: Reflections on an Industry in Chaos after World War Two," 15.

losing their voice, and subsequently their market, many traditional terra cotta manufacturers were forced to fend for themselves.

Many factories folded when fierce competition with the cheaper production costs of materials such as concrete and glass was compounded with bad publicity from deteriorating terra cotta buildings dating from the turn of the century. The transition to steel frame construction forced terra cotta manufacturers to analyze the physical and chemical properties of their material.

When terra cotta was first introduced in the construction industry it was hailed as a cheaper substitute for stone. The use of plaster molds for the terra cotta repeater pieces allowed for faster production as opposed to carving each piece individually as done with stone. It was lightweight, durable, moldable, and colorful. It could be made to look like many structural stones but was less susceptible to weathering.⁵⁵ However, the industry faced some problems during production in controlling warping and shrinkage of the blocks. After construction, differences in temperature could not only affect the physical properties of the internal structure of the wall but also enabled spalling of the glaze from the body of the block. Cracked fire skins and weak mortar joints after installation allowed water to penetrate the interior of the wall causing serious damage to the mortar filling or the iron anchors supporting the block.⁵⁶ Water penetrating the wall through cracks, joints, or spalled areas, threatened the structural integrity of the blocks as well as their aesthetic qualities.

⁵⁵ Meadows, *Historic Building Facades: A Manual for Inspection and Rehabilitation*, 23.

⁵⁶ Ibid.

The roots of these problems extended beyond the quality of the terra cotta being produced by the companies to the fundamental business practices of the manufacturers themselves. Failures were blamed on flimsy specifications, the installation of the blocks on site, and faulty design of the wall construction systems. As explained in the previous section, most manufacturers went through a laborious process of drafting, molding, firing, and fitting the pieces to ensure quality. Once the pieces reached the site, however, there was minimal guidance over the actual installation or protection against human error. Additionally, since there had been little physical testing of the material, some the common anchoring techniques were not sufficiently supporting their loads. As a result, the companies tried to create standard specifications, investigated the physical properties of the material, and hired their own masons. A definitive set of standards was not published until 1927 and even these did not include all the information learned from the testing. By the time the depression hit in the 1930s, the public opinion of the material was severely damaged.

CHAPTER 2 : ORGANIZATION OF THE INDUSTRY

BUSINESS DEVELOPMENT

“More big contracts are closed over nuts and wine than across a desk.”

—Andrew Carnegie of Carnegie Steel⁵⁷

From 1886 to 1960, terra cotta manufacturers endeavored to organize the industry to stimulate business, protect individual investments, and standardize construction. Terra cotta manufacturing came about during the age of “Big Business” in America where cut throat competition from major competitors wiped out smaller companies. At the turn of the century on the East Coast, a number of organizations were created to control the market and evenly distribute the numerous contracts. Eventually, as the government began to enforce the Sherman Antitrust Act of 1890, the organizations focused heavily on the dissemination of information about the material in the forms of advertising, publications, and trade literature. With the advent of new construction techniques and damaging publicity about the failures of terra cotta, a group of manufacturers began to cooperate to eliminate outdated construction techniques and harmful business practices. With issues such as modernization, newer cost-effective materials, and loss of craftsmen in the 1960s, the manufacturers once again organized to provide business opportunities for each company and to inform the country about modern applications of the material.

Modern innovations have propelled industry throughout the history of the United States. By the end of the nineteenth century, three important advancements led the way for

⁵⁷“Architectural Terra Cotta,” *Brick and Clay Record*, no. 33, Walter Geer, *The Story of Terra Cotta* (New York,: T. A. Wright, 1920), 97.

industrialization in America: the railroad, the telegraph, and steel.⁵⁸ The terra cotta industry, for example, flourished as factories located on rail lines could deliver materials to clients in other states who wanted to clad and fireproof their skeletal frame skyscrapers.⁵⁹ Businesses of this type grew “vertically” by usually engaging, “in a number of different activities, such as purchasing or growing its raw materials, fabricating those materials into goods, transporting its own products, wholesaling them, or even taking care of retailing them to consumers.” The other option was to grow “horizontally” when a “number of producers who all did the same thing would join together to form a combination of their interests.”⁶⁰ Like some of the larger enterprises of this period, the terra cotta industry developed in both directions. The first chapter of this paper outlines the manufacturing process of terra cotta which closely follows this pattern of “vertical growth.” Taking a step further, many manufacturers even installed their final product using their own masons and company-supplied iron anchors.⁶¹ The following section traces the “horizontal growth” of the industry as it endeavored to maximize demand, stabilize prices, and minimize competition.

Standard Oil, American Sugar Refining, and American Tobacco –successful trusts in the 1880s –undoubtedly influenced the terra cotta manufacturers with their ability to effectively control the market. Before 1886, George M. Fiske of the Boston Terra Cotta

⁵⁸ Glenn Porter, *The Rise of Big Business: 1860-1920*, 2nd ed. (Arlington Heights, Illinois: Harlan Davidson, Inc., 1992), 41-45.

⁵⁹ O. W. Ketcham specifically purchased the site for his factory because it was located on the Pennsylvania Railroad. “It allowed for the large volumes of clay to come into the plant, and in the case of distantly located large orders, allowing for the shipping of the finished terra cotta to a siding close to the job site.” See: Barton, “O. W. Ketcham Terra Cotta: Reflections on an Industry in Chaos after World War Two,” 12.

⁶⁰ Porter, *The Rise of Big Business: 1860-1920*, 46.

⁶¹ Mack, “The Manufacture and Use of Architectural Terra Cotta in the United States,” 137.

Company and Harry A. Lewis of the H. A. Lewis Architectural Terra Cotta Works (Boston) realized they were not capitalizing on all the contracts available to them.⁶² As Glenn Porter explains in *The Rise of Big Business: 1860-1920*, this was a common phenomenon among growing industries before 1895:

First, a number of manufacturers would enter an industry, producing goods in volume in factories that sometimes required quite substantial capital investment. For a time, all would be well. Profits would be good, and the business would expand, often leading others to enter the industry to share in the promise of prosperity. As the market began to fill up, however, producers found that they had to compete vigorously in order to keep or to enlarge their share of the market. Most manufacturers tried to do so by cutting the prices on their goods. After a period of sharp price competition, they would find that profits and prices were not meeting their expectations and would begin to search for a solution to this problem.⁶³

Fiske and Lewis' solution was the "Open Price" system in which they agreed to divide contracts between them based on need in order to mutually benefit each other. William C. Hall from the Perth Amboy Terra Cotta Company refined this plan and called a meeting in the winter of 1886 to organize the major manufacturers on the East Coast. This meeting resulted in the formation of the First Brown Association. The organization adopted an "elaborate set of rules" for a contract distribution process and was administered by a central agent in the New York office.⁶⁴ Similar associations were known to provide a "convenient format in which they might agree to fix prices, set output quotas, or divide the market in some manner, such as by apportioning geographic territories among the members of the association."⁶⁵ The five members of the First Brown Association included: the Perth

⁶² Geer, *The Story of Terra Cotta*, 97-98.

⁶³ Porter, *The Rise of Big Business: 1860-1920*, 58-59.

⁶⁴ Geer, *The Story of Terra Cotta*, 98-100.

⁶⁵ Porter, *The Rise of Big Business: 1860-1920*, 59.

Amboy Terra Cotta Company, the Boston Terra Cotta Company, the New York Architectural Terra Cotta Works, the H. A. Lewis Terra Cotta Works, and the A. Hall Terra Cotta Company.⁶⁶

The First Brown Association stabilized the industry for a few years but was soon threatened by competition from a Philadelphia company: Stephens, Conkling and Armstrong. Often these associations failed as periods of profit encouraged new manufacturers to open shop, leading to increased competition, plummeting prices, and eventually, profit losses.⁶⁷ To overcome this zigzag in the bottom line, the Second Brown Association was formed in 1893 to include the Philadelphia manufacturer.⁶⁸ The group's first attempt to smooth out the competition was to eliminate the smaller companies. Porter states, "Often, the most effective way to maintain market position and profits was to become more competitive by ordering the closing of the less efficient plants."⁶⁹ A. Hall Terra Cotta Company and the Boston Terra Cotta Company –the smaller companies –were eventually disbanded. H. A. Lewis Terra Cotta Works was bought out by Perth Amboy and became a Philadelphia branch for the company. Stephens, Conkling, and Armstrong was annexed by New York Architectural Terra Cotta Company and served as a Philadelphia branch for that company. For the next two years, the only members of the Association were Perth Amboy and New York. Despite these attempts to suppress competition, seven new manufacturers sprung up replacing the four companies that were disbanded including: Standard (1890), White (1892), Staten Island (1893), New Jersey

⁶⁶ Geer, *The Story of Terra Cotta*, 99.

⁶⁷ Porter, *The Rise of Big Business: 1860-1920*, 60.

⁶⁸ Geer, *The Story of Terra Cotta*, 102-05.

⁶⁹ Porter, *The Rise of Big Business: 1860-1920*, 61.

(1893), Excelsior (1894), Conkling-Armstrong (1895), and Corning (1896). At this point, business conditions were worse than before any attempts at organization.⁷⁰

With the fledgling companies flailing and the established companies losing bids, there was another attempt at organization by the manufacturers in 1896. Porter explains, “Usually, the next step after the failure of the association strategy was an attempt at horizontal combination, in which all or many of the major producers in an industry would form a single firm, at least in the legal sense.”⁷¹ The producers of terra cotta created an incorporated company with \$10,000 in capital known as the Manhattan Material Company. Walter Geer explains:

The Manhattan Company was to act as the general sales agency of the various companies interested, and entered into contracts with different companies individually, agreeing to turn over to each company a certain percentage of the total amount of orders secured by said Manhattan Company, these percentages being the same as the percentage of stock held by each company. In the case the Manhattan Company for any reason could not assign to any individual company its exact quota of orders, it agreed to pay in cash a bonus of twenty percent of the amount of such deficit, and any company receiving more than its quota agreed to pay to the Manhattan Company a similar amount by way of penalty.⁷²

Such an agreement prevented a single company from getting more contracts than it could handle as well as ensured each manufacturer would receive sufficient contracts to remain in business. Of the six members –Perth Amboy, New York, Standard, Excelsior, Conkling-Armstrong, White, and New Jersey –each signed a five year contract agreeing to these terms and fixed percentages. Competition ensued, however, with the establishment of the

⁷⁰ Geer, *The Story of Terra Cotta*, 96-106, 21.

⁷¹ Porter, *The Rise of Big Business: 1860-1920*, 60.

⁷² Geer, *The Story of Terra Cotta*, 123.

Brick Terra Cotta and Tile Company (Coming, 1896) and the Atlantic Terra Cotta Company (1897) making the Manhattan Company defunct by 1901.⁷³

The Eastern manufacturers were determined the only way to protect their interests was to stabilize prices and output to ensure profits. This method in the early years of the twentieth century was “especially common in new industries and in those that underwent significant technological changes involving high capital investment and high fixed costs.”⁷⁴ In 1902, the Terra Cotta Manufacturer’s Association was instituted following a similar business plan as the Manhattan Company. Previously there were many complaints about the assignment of fixed percentages which determined the amount of work a particular company would receive. Now the percentages were assigned according to a sliding scale determined by work acquired during a particular amount of time. Some felt “the companies might just as well have installed a roulette wheel and left the fate of the business to the decision of chance.”⁷⁵ Attempts at organization failed again and the association was dissolved in 1904.

At this point, more terra cotta producers were entering the business: South Amboy Terra Cotta Company (1903), Maryland Terra Cotta Company (1905), O. W. Ketcham Terra Cotta Works (1906), and anti-trust laws were fully enforced. Several schemes were created to improve the industry including the formation of the National Terra Cotta Company which was to merge all the major East Coast companies into one. This idea led to the formation of the Atlantic Company in 1907 which detrimentally combined the old

⁷³ Ibid.

⁷⁴ Porter, *The Rise of Big Business: 1860-1920*, 65.

⁷⁵ Geer, *The Story of Terra Cotta*, 145.

Atlantic, Perth Amboy, Excelsior, and Standard companies.⁷⁶ For other similarly combined industries from this period, “the new corporation often functioned for a time as a loose amalgam of divisions that retained much of their former autonomy.” The central office did little more than make decisions on prices, output, and marketing unless outside forces, such as increased competition, forced the company, “to take away the autonomy of its subdivisions and exercise more unified control.”⁷⁷ With plenty of competition still alive and a general depression in 1907, business was worse then ever before causing some major executives to pull out of the company.⁷⁸

The Sherman Act of 1890 was passed as an attempt to curtail “Big Business” and encourage the smaller, specialized entrepreneurs that supported a healthy economy. This vague law was intended to suppress “Big Business” but was being interpreted in the courts to encourage incorporation. Porter explains this paradox:

The courts ruled that forms of cartel-like behavior were illegal under the act, but that unified combinations were in most instances acceptable. That is, the law forbade collusion by independent firms but did not necessarily outlaw the activities of integrated holding companies created by the legal union of previously separated businesses.⁷⁹

The evolution of organization within the terra cotta industry follows these business trends at the turn of the twentieth century. In order to maximize the benefits in the 1880s, the manufacturers entered into cartel-like associations to control the market. Soon after the passage of the Sherman Antitrust Act in 1890, they began to incorporate as holding

⁷⁶ Ibid., 143-50.

⁷⁷ Porter, *The Rise of Big Business: 1860-1920*, 61.

⁷⁸ Geer, *The Story of Terra Cotta*, 150.

⁷⁹ Porter, *The Rise of Big Business: 1860-1920*, 77.

companies. By 1911, as the government began cracking down on “Big Business” as exemplified in the forced dissolution of Standard Oil into multiple firms, terra cotta manufacturers changed their goals from price-fixing towards production efficiency.

In the early twentieth century, “efficiency” to the manufacturers translated as upsurges in demand, publicity, and technology. This attitude mimicked the new trends in competition that strove for, “the most efficient systems of organization for production and distribution, and a never-ending effort to plan, to react to changing circumstances, and to allocate resources so as to keep the enterprise growing via new products and services.”⁸⁰ In 1910, the terra cotta manufacturers proposed to create a “Literary and Publicity Bureau” to “spread knowledge of the many advantageous qualities of good architectural terra cotta by widely advocating its merits, particularly through the agency of wise advertising and the publication of books, pamphlets, and other forms of trade literature.”⁸¹ The bureau was never created but its goal was incorporated into the National Terra Cotta Society formed in 1911. This was the most successful organization of manufacturers in the history of terra cotta. For this first time, collaborative efforts focused on improvements to the material, promotional strategies, and distribution of knowledge about terra cotta construction. This valiant organization is described in detail in the next section of this chapter. Unfortunately, the Society eventually shared the fate of previous organizations. It was dissolved in 1934 as a response to the depressed economy, competitive new materials, and high dues.⁸²

As the market changed in the mid-twentieth century toward sleek, modern materials, the few existing manufacturers continued attempts to organize themselves and

⁸⁰ Ibid., 89.

⁸¹ Geer, *The Story of Terra Cotta*, 151, 236.

protect the industry. In the mid-1930s, the National Terra Cotta Manufacturers Association was created followed by the Architectural Terra Cotta Institute (1947-59), the Structural Clay Products Institute (1960s), and the Brick Institute of America⁸³ which still exists.⁸⁴

The National Terra Cotta Manufacturers Association was a short lived attempt to boost the industry initiated by the mid-western companies –American, Indianapolis, Kansas City, Midland, Northwestern, Western, and Winkle.⁸⁵ The association was soon replaced by the Architectural Terra Cotta Institute in 1947 which included the seven remaining companies in the country: American Terra Cotta Corporation (Chicago), the Denver Terra Cotta Company, the Federal Seaboard Terra Cotta Corporation (Perth Amboy, NJ), Gladding, McBean and Co. (California), O.W. Ketcham Terra Cotta Works (Philadelphia), the Northwestern Terra Cotta Corporation (Chicago), and the Winkle Terra Cotta Incorporated (St. Louis). The goals of this organization were:

1. To educate building professionals about the uses and properties of terra cotta
2. To address the shortage of trained terra cotta craftsman
3. To compile statistics on the quantities of terra cotta being bought throughout the United States
4. To manufacture new products that would be appropriate for the architectural styles of the period

⁸² Tunick, *Terra-Cotta Skyline : New York's Architectural Ornament*, 107.

⁸³ www.bia.org

⁸⁴ Tunick, *Terra-Cotta Skyline : New York's Architectural Ornament*, 107.

⁸⁵ Michael Fus, "Architectural Terra Cotta: Standards, Specifications, and Testing" (Master of Science, Art Institute of Chicago, 1997), 59.

As with previous terra cotta organizations, the dues structure based on sales percentages and competition over new products forced many companies to withdraw from the Institute.⁸⁶

The Architectural Terra Cotta Institute and later the Structural Clay Products Institute produced standard specifications for terra cotta in 1954 and 1961, respectively. The theme of improving the product and standardizing construction began with the proposed Literary and Publicity Bureau in 1910 and was implemented in the work of the National Terra Cotta Society from 1911-1934.⁸⁷ These later institutions continued the tradition but have since been absorbed into the Brick Institute of America which publishes information on brick products but not terra cotta.⁸⁸

The terra cotta industry has significantly diminished since its American debut in the nineteenth century. Porter claims:

The most important factor in accounting for the rise and persistence of big business has been that giant firms were most likely to appear and to succeed if they were in technologically advanced industries that could achieve and sustain genuine economies of scale and could link mass production to mass distribution.⁸⁹

In the end, the terra cotta industry struggled with technology trends in new architecture, wavering demand levels, and slow production rates. These are the fundamental reasons all the attempts at organizing the industry eventually failed.

⁸⁶ Tunick, *Terra-Cotta Skyline : New York's Architectural Ornament*, 114-15.

⁸⁷ Geer, *The Story of Terra Cotta*, 151.

⁸⁸ Tindall, "How to Prepare Project Specific Terra Cotta Specifications." See Tindall's footnote #23.

⁸⁹ Porter, *The Rise of Big Business: 1860-1920*, 86.

“National Terra Cotta Society is a bureau of service and information operating for the Terra Cotta manufacturers of the United States.”

—NTCS Advertisement⁹⁰



Figure 7: The National Terra Cotta Society (1927). Photo is from the Ketcham Collection at the Athenaeum of Philadelphia. For list of those photographed see Appendix A: NTCS Members.

Until 1911 most efforts at organization for the terra cotta industry did little to improve business. Walter Geer of the New York Architectural Terra Cotta Company had been instrumental in the formation of the Second Brown Association, the Manhattan Company, and the Literary and Publicity Bureau project. Therefore, it was not unusual that Walter Geer opened correspondence with all the manufacturers to create a national organization in 1911. This time the organization would serve as an advocate for terra cotta

⁹⁰ National Terra Cotta Society, "A Campaign for Better Understanding," *Pencil Points* 1, no. 6 (November 1920).

interests. The National Terra Cotta Society (NTCS) not only worked to standardize the industry but also to introduce a Code of Ethics, to conduct tests on the nature of the material, and to inform other industries of their work.

The first meeting was arranged by Walter Geer, Gustav Hottinger of the Northwestern Terra Cotta Company, and P. McGill McBean of Gladding, McBean and Company. It was held on December 8, 1911, in Chicago at the Hotel La Salle and attended by 23 delegates from companies across the country.⁹¹ A set of by-laws and a constitution were adopted at the meeting and officers were elected. The officers included: President- Fritz Wagner of the Northwestern Terra Cotta Company, First VP: Walter Geer of the New York Architectural Terra Cotta Works, Second VP: W.E. Dennison of Steiger Terra Cotta and Pottery Works, Treasurer: E. V. Eskesen of the New Jersey Terra Cotta Company, and Secretary: W. D. Gates of the American Terra Cotta and Ceramic Company.

Most importantly, five objectives were adopted at the meeting which clearly outlined the purpose of the organization. These objectives were:

⁹¹ *Delegates Represented-* Brick Terra Cotta and Tile Co.- Corning, NY, M.E. Gregory; Conkling-Armstrong Terra Cotta Co.- Philadelphia, PA- I.L. Armstrong and T.F. Armstrong; Federal Terra Cotta Co.-Woodbridge, NJ - De Forest Grant and Norman Grant; New Jersey Terra Cotta Company- Perth Amboy, NJ- Karl Mathiasen and E. V. Eskesen; New York Architectural Terra Cotta Co.-New York, NY-Walter Geer, F. C. Townshend, and H.J. Lucas; South Amboy Terra Cotta Company-South Amboy, NJ- P.C. Olsen; American Terra Cotta and Ceramic Company- Chicago, Il.- W.D. Gates and E.D. Gates; Northwestern Terra Cotta Co.- Chicago, Il.-G. Hottinger and F. Wagner; St. Louis Terra Cotta Co.- St. Louis, MO-D.N. Burruss and R.F. Grady; Western Terra Cotta Co.- Kansas City, KS- William Timmerman; Winkle Terra Cotta Co.- St. Louis, Mo.- Joseph Winkle and J.G. Hewitt; Gladding-McBean-and Co.-San Fran., CA- P. McGill McBean; N. Clark and Sons, San Fran., CA- Mr. McBean (Proxy) Northern Clay Co.- Auburn, WA- P.S. MacMichael; Steiger Terra Cotta and Pottery Works, San Fran., CA- W.E. Dennison (resigned or withdrew (1918)

Supported by but did not attend- O. W. Ketcham Terra Cotta Works- Philadelphia, Pa- O.W. Ketcham; Maryland Terra Cotta Co- Baltimore, MD- (resigned 1915); Indianapolis Terra Cotta Co. Indianapolis, IN.; Denny-Renton Clay and Coal Co.- Seattle, WA; Washington Brick, Lime, and Sewer Pipe Co.- Spokane Washington

Six other members admitted later- Midland and Denver (1912); Kansas City (1913); Atlanta and Atlantic (1915); Los Angeles (1919)

Geer, *The Story of Terra Cotta*, 234-35.

1. To encourage the production of the best materials and the maintenance of high and uniform standards of work
2. To spread the knowledge of the many advantageous qualities of good architectural terra cotta by widely advocating its merits, particularly through the agency of wise advertising and the publication of books, pamphlets, and other forms of trade literature.
3. To co-operate in the investigation and study of the more important technical and other problems of the business
4. To advance mutual business interests in every legal and proper way, without in any manner, directly or indirectly, agreeing to maintain prices or suppress competition
5. To promote a feeling of confidence and friendship among the members, so as to secure the benefits of the several objects above set forth

The last two objectives clearly represent how the industry has struggled with organization attempts in the past. Objective number four is a response to the anti-trust mentality of the time and most likely the industry's previous attempts at controlling competition. Geer states:

At this time, the government at Washington, under President Roosevelt's Administration, had begun to vigorously enforce the Sherman Act, which had been adopted over ten years before, and Big Business for the first time realized that the law had teeth... The Terra Cotta manufacturers had no intention then, or at any other period, of acting contrary to the law⁹²

The last objective most likely refers to the messy hangover from the suppressed competition that ensued after the merger of the Atlantic Company in 1907. Geer explains that this company failed to respect the weaker competitors as well as the multi-pronged business practices of the merged companies. By 1909, some executives left the company and legal proceedings –including an investigation by the Federal Grand Jury–

⁹² Ibid., 147-8.

unsuccessfully attempted to dissolve the company and return the old Atlantic company to its original owners.⁹³

The notion of cooperation and friendship among the manufacturers as implied in the first objective was a crucial element for standardization and material improvement. The Society functioned as a clearing house of information collected from all the members, synthesized, and redistributed. For example, in 1914 there was growing concern about the various qualities of terra cotta available on the market. Mr. O. Wenderoth, Supervising Architect of the Treasury and potential client, wrote to the Society demanding, “a terra cotta specification very exacting in the matter of quality, yet fair and reasonable for the first class manufacturer.”⁹⁴ He also explained to the Society, “unless he can get good architectural terra cotta, he will use no architectural terra cotta. He appreciates that this material has many qualities when well made, properly set and carefully pointed, but he also knows that there are several qualities of ware on the market, good, bad, and indifferent.”⁹⁵ This correspondence was preceded by Wenderoth’s inquiry to various terra cotta manufacturers about the specification of models in the factory and general manufacturing processes. Harry J. Lucas, Assistant Secretary of the NTCS, responded quickly by sending notices to Society members about the request for standardization saying that:

This is an important matter and it is very desirable that we now attempt to standardize the processes referred to by the Supervising Architect...The Eastern Division will make a definite recommendation in this matter with the next few

⁹³ Ibid., 150.

⁹⁴ Harry J. Lucas to C. L. H. Wagner, September 10, 1914, New York Architectural Terra Cotta Company Collection, Columbia University Avery Library. See Appendix B: Correspondence and Advertisements

⁹⁵ Ibid.

days, and same will be submitted to the larger companies in other Divisions for general approval before transmission to Washington.⁹⁶

By September 10, 1914, Lucas sent out a draft of the model specifications for approval. This process of communication and cooperation among the Society members enabled the manufacturers to streamline production efforts as well as entice architects to use the material.

Educating architects about the qualities of terra cotta was a primary goal of the NTCS and this was done mostly through publications and advertising. A letter to all members of the NTCS on April 15, 1915 states:

All publications of the Society are distributed by and in the name of the Society from its executive officers. Agents who are sure that certain architects, owners, or other can and will make good and valuable use of this literature should send names, with facts, to the company they represent... These books are costly and should be distributed only where they are likely to make terra cotta business.⁹⁷

The Society believed that in order to sell its product, they had to show beautiful examples of existing terra cotta buildings. In April of 1916 they collected 10 photographs from members of terra cotta storefronts of all designs.⁹⁸ These photographs would represent the work of all the Society members in the 1915 brochure, "The Store." The Society depended on the working knowledge of its members in order to produce such seminal publications as "Architectural Terra Cotta: Standard Construction, 1914" and "Terra Cotta Standard

⁹⁶ Harry J. Lucas to New York Architectural Terra Cotta Company, August 20, 1914, New York Architectural Terra Cotta Company Collection, Columbia University Avery Library. See Appendix B.

⁹⁷ Harry J. Lucas to Agents Representing Terra Cotta Manufacturers Who Are Members of the National Terra Cotta Society, April 13, 1915, New York Architectural Terra Cotta Company Collection, Columbia University Avery Library. See Appendix B.

⁹⁸ William H. Powell to The Members of the National Terra Cotta Society, April 10, 1916, New York Architectural Terra Cotta Company Collection, Columbia University Avery Library. See Appendix B.

Construction, 1927.” These marketing tools were embellished by advertisements in popular trade journals including *The Architectural Forum*, *The Brickbuilder*, and *Pencil Points*. The title of one advertisement in a November 1920 issue of *Pencil Points*, “A Campaign for Better Understanding,” illustrates how the Society attempted to spread the word about the merits of the material.⁹⁹ This was one of many advertisements designed “not only to increase public admiration for the Architect and his judgment, but to set forth, as well, the practical and aesthetic qualities of Terra Cotta as an architectural material of permanence, beauty, and profit.”¹⁰⁰ These advertisements and publications promoted the industry as a whole yet benefited the manufacturers individually as their sales increased.¹⁰¹

One of the most successful accomplishments of the National Terra Cotta Society was the streamlining of business practices throughout the industry. This included not only investigating technical aspects of the material but also uniformity of forms and contracts. The American Institute of Architects initiated standardization of forms for their industry in 1907 and published, “The Standard Documents of the American Institute of Architects” in 1911.¹⁰² They justified this effort as an attempt to, “improve the form of certain documents currently used by architects, with a view to making these documents clear in thought and statement, equitable as between owner and contractor, applicable to work on almost all

⁹⁹ Society, “A Campaign for Better Understanding.” See Appendix A.

¹⁰⁰ Ibid.

¹⁰¹ Fus, “Architectural Terra Cotta: Standards, Specifications, and Testing”, 162.

¹⁰² This document was found in the files of Walter Geer, then President of the New York Architectural Terra Cotta Company and Vice President of the National Terra Cotta Society. Along with the brochure in the files were copies of standard forms used by the company. These finds indicate Geer and the Society were researching other industry techniques for standardization. New York Architectural Terra Cotta Company Collection, Columbia University Avery Library, 1916. American Institute of Architects, *The Standard Documents of the American Institute of Architects* (Washington, DC: The American Institute of Architects, 1911).

classes, binding in law and a standard of good practice.”¹⁰³ To produce these documents, the Standing Committee on Contracts and Specifications synthesized forms used by thirty different architects. The NTCS followed this precedent by creating a Contract Committee to collect forms used by the terra cotta manufacturers and standardize them. In a letter addressed to all members in 1916, committee member William H. Powell, President of the Atlantic Company, requests copies of estimate forms used by all members in order to make sufficient revisions to the standard form.¹⁰⁴ In the past, terra cotta manufacturers had difficulty communicating with contractors and architects which led to installation problems and premature deterioration. Standardized forms, particularly standard specifications, allowed the architects, contractors, and terra cotta manufacturers to communicate on the same level and construct better buildings.

The theme of improved communication can be traced through all of the NTCS efforts whether it was with other terra cotta manufacturers, potential clients and contractors, or even other professional organizations. For example, in 1919, the NTCS set up a committee to serve as a liaison with the American Ceramic Society (ACS). ACS, highly involved in the technical aspects of terra cotta, instituted ceramic departments at many universities throughout the country.¹⁰⁵

NTCS was able to set up a Terra Cotta Division within ACS which was coordinated by the NTCS Standing Committee on Technical Matters. This division, in conjunction with the United States Bureau of Standards, began investigations into, “fifteen separate and

¹⁰³ Ibid.

¹⁰⁴ Powell to The Members of the National Terra Cotta Society, See Appendix B.

¹⁰⁵ Geer, *The Story of Terra Cotta*, 240.

distinct subjects...covering practically all phases of terra cotta manufacture.”¹⁰⁶ Research and testing at the United States Bureau of Standards was funded through a fellowship of the NTCS and the ACS and lasted from 1915 to 1945. The investigation of terra cotta determined physical properties of clays, grog, and bodies, expansion of glazes, expansion of underslips, and sources of faulty construction. Further studies of construction techniques examined movements in buildings, joints, filling for terra cotta, concrete construction, anchoring metals, flashing, salt crystallization, and cracking.¹⁰⁷ To accomplish this enormous task, the Bureau examined samples two to thirty years old from 535 buildings in every major city east of Kansas City, Missouri.¹⁰⁸ The investigators additionally visited fourteen different terra cotta plants to analyze and compare the different methods of manufacture. This information was made available to Society members in bi-annual reports that included recommendations for improving construction techniques.¹⁰⁹

Besides the American Ceramic Society, NTCS was in contact with many other organizations. Often, a member of the Society would be a representative for the terra cotta industry at various conventions or meetings. For example, H. G. Richey, President of the Society of Constructors of Federal Buildings, requested that the Northwestern Terra Cotta Company give, “a heart to heart talk from the manufacturer’s or producer’s standpoint” on the use of terra cotta in United States Public Buildings at a meeting on January of 1915 in

¹⁰⁶ Ibid.

¹⁰⁷ National Terra Cotta Society, Summary and Index of Reports One to Eight Relating to the Technical Work of the National Terra Cotta Society (The National Terra Cotta Society Fellowship at the National Bureau of Standards, New York, 1918-1922),

¹⁰⁸ “Architectural Terra Cotta Investigations,” *NBS Technical News Building* 8, no. June (1925). “Architectural Terra Cotta Investigations,” 4.

¹⁰⁹ Assumed from the index of the report which two publication dates per year. .

Washington, DC.¹¹⁰ This organization mostly consisted of employees from the United States Treasury Department, Supervising Architect's Office. In this case, previous efforts of the NTCS to work with this office over the modeling specifications in the Fall of 1914 paid off.¹¹¹ Fritz Wagner of the Northwestern Terra Cotta Company re-routed this request to the National Terra Cotta Society. The Society then dispatched the most appropriate representative to deliver the speech and tout the advantages of terra cotta for potential government contracts.¹¹²

The trade journals and especially the published standards of the NTCS have had a lasting effect in the built environment as they provide insights into the original construction practices of this historic building art. Despite the best efforts of the few manufacturers to keep the industry alive in the mid-twentieth century, terra cotta fell out of favor with architects and masons. Yet, a rich legacy of terra cotta buildings erected in the nineteenth and early twentieth century survives throughout the United States. By tracing the evolution of the material through the standards and specifications written during its peak of production, the craftsmanship of the material can be revived through carefully implemented preservation plans by terra cotta conservators.

¹¹⁰ H.G. Richey to Northwestern Terra Cotta Company, November 6, 1914, New York Architectural Terra Cotta Collection, Columbia University Avery Library. See Appendix B.

¹¹¹ See page 10 for discussion on the correspondence between the Treasury Department, Supervising Architect's Office and the National Terra Cotta Society about modeling specifications.

¹¹² F. Wagner to H. G. Richey, November 9, 1914, New York Architectural Terra Cotta Company Collection, Columbia University Avery Library. See Appendix B.

CHAPTER 3 : STANDARDIZATION

“Like many other things in the affairs of life, the use of iron as an ally to terra cotta becomes censurable only when it is abused, by being applied in the wrong place, or in an injudicious manner, and (as often happens) when no extraneous support is required.”

—Thomas Cusack¹¹³

There are no specifications written to guide the replacement of terra cotta in historic buildings.¹¹⁴ Beyond understanding the development of the material and its physical properties, the conservator must acknowledge the technological abilities used at the time of construction in order to develop a successful preservation plan. Specifications and standards from this era provide insights into the construction knowledge and practices of the terra cotta industry. While shop drawings illustrate size, form, location, and design of the terra cotta blocks, “specifications, on the other hand, describe the quality of materials, processes, and workmanship required to complete a building.” In fact, “they are, by their very nature, a device for organizing the information depicted on the drawings.”¹¹⁵ Standards are another tool used to simplify construction. In an attempt to inform those outside the industry about proper installation techniques, the terra cotta industry produced a booklet on standard construction for distribution to all of their clients. Specifications for terra cotta, once written to describe the physical appearance of the final product, began to delineate the roles of the contractors to facilitate the use of the material in construction projects. The standards and specifications of terra cotta were intended to address the

¹¹³ Thomas Cusack, "Architectural Terra Cotta," *The Brickbuilder* 5 (1896): 51-52.

¹¹⁴ Tindall, "How to Prepare Project Specific Terra Cotta Specifications," 26.

¹¹⁵ Harold J. Rosen, *Principles of Specification Writing* (New York: Reinhold Publishing Corporation, 1967), 21.

material's issues of compatibility with structural steel, of design in the architect's plans, and of quality construction (especially anchorage) at the project site.

Before the skeletal steel frame transformed architectural practices in the late nineteenth century, the architect relied on terra cotta manufacturers' expertise for joint placement, setting plans, and anchoring systems. As steel was integrated into the buildings, each profession had to compensate for the learning curve associated with new installation techniques, new load distribution, and new volumes of material. As for the terra cotta manufacturer:

Hitherto, he had been able to discuss and determine all questions with the architect; who in view of the points involved, would usually agree to any well-considered alternative that might be proposed in jointing or otherwise. With the advent of an independent skeleton, he soon found that a new terror had been added to his already onerous existence. The architectural engineer—a veritable man of iron—had now to be reckoned with.¹¹⁶

Cooperation among the three professionals—architect, terra cotta manufacturer, and engineer—was the key to successful construction. In the 1890s, however, confusion ensued as communication broke down during the fast paced construction period. Often, when inconsistencies were discovered between the fit of the terra cotta and the steel, production of either material was too far along to be modified. Trade journals from the time explain:

Instead of terra cotta being one of the first items pushed forward to a definite settlement, it is often allowed to drag until nearly the last, or until some general contractor can make satisfactory terms with one out of many subcontractors. Meanwhile, the iron construction has been determined, and is then, perhaps, too far advanced at the works to admit of any modification being made, however freely certain oversights may be admitted.¹¹⁷

¹¹⁶ Thomas Cusack, "Architectural Terra Cotta," *The Brickbuilder* 7, no. 1 (1898): 7.

¹¹⁷ *Ibid.*, no. 3: 55.

This resulted in costly adjustments to the building on-site either to the steel frame or most likely to the terra cotta webbing. Such abominable decisions often led to premature deterioration and highlighted the need for standard practices and procedures.

EARLY SPECIFICATIONS AND STANDARDIZATION

We are aware of the objections that have been urged against the principle of composite construction, such as we now propose to discuss, but they are all of a purely academic kind and may be put to rest without extended argument. A bare recital of the stubborn facts of everyday practice, in which iron and steel are being so extensively used to supplement or displace other materials, furnishes a conclusive answer. There is no inherent antagonism between these two materials which in their natural state are closely allied.

—Thomas Cusack¹¹⁸

The trade journals, such as *The Brickbuilder*, recognized this need for standardization and began publishing articles about proper anchoring techniques and division of labor. But it was not until 1905 that the first specifications were published in *The Brickbuilder* and 1914 that the first standards were published by the NTCS. The specifications written by Charles P. Warren, an architectural construction professor at Columbia University, were organized by trade responsibility and accompanied by an explanation of the manufacturing process and detailed drawings.¹¹⁹

Most importantly, his specifications attempted to define the role of each subcontractor—the mason, the iron contractor, the terra cotta contractor, and the carpenter—as previous failures to do so had, “led to no end of confusion and disputes and in some

¹¹⁸ Cusack, “Architectural Terra Cotta,” 51-52.

¹¹⁹ Fus, “Architectural Terra Cotta: Standards, Specifications, and Testing”. See chapter II for a thorough discussion on the evolution of the terra cotta specifications from 1905-1950s.

cases even to strikes.”¹²⁰ The mason was in charge of the terra cotta blocks from the moment they were delivered to the moment they were installed on the building. He was also responsible for providing “all ironwork which is not bolted or riveted to the structural work” and all things necessary for setting the material from mortar to scaffolding. The iron contractor “always furnishes and sets all iron or steel work which is fastened or connected the structural work or frame of the building.” The terra cotta contractor was required to deliver the material in carefully packed rail cars, furnish detailed drawings showing all necessary ironwork to the architects, and create setting plans for the masons. The carpenter was required to set all arches as well as protect any projecting courses during the construction phase. Above all, it was the architect’s responsibility to coordinate all the sub-contractor’s activities. Warren attempted to ease on-site construction practices for terra cotta but anchoring techniques still remained unclear.¹²¹

The National Terra Cotta Society, in accordance with their fundamental goal “to encourage the production of the best materials and the maintenance of high and uniform standards of work,” produced the seminal publication on standard construction practices for terra cotta in 1914. This book included seventy plates of terra cotta drawings in section, plan, and elevation for a variety of entrances, balconies, balustrades, wall copings, windows, cornices, columns, domes and many other elements. The introduction to the book addresses the controversial construction practices of the time as, “unfavorable shapes or dimensions, or arbitrary arrangement of engaging or supporting materials may not only increase the cost of production and of erection, but may also produce unsatisfactory results,

¹²⁰ Charles P. Warren, “Notes on the Standard Form of Specifications for Architectural Terra Cotta,” *The Brickbuilder* 14: 8.

¹²¹ *Ibid.*

both aesthetically and constructively.” As a result, the plates show ideal placement of typical terra cotta blocks with typical iron framed buildings. They also illustrate common hanging and anchoring systems used by the leading terra cotta manufacturers as well as detailed information on the individual types of the iron anchors themselves. The Society not only produced these standards to promote business, but also, “to save time, trouble and expense to all concerned by disseminating accurate and dependable information on proper methods of jointing and construction.”¹²²

ADVANCES IN SPECIFICATIONS AND STANDARDS IN THE 1920S

Two essentials are involved in the use of a building material and often these are practically of equal importance. The material itself: its manufacture, physical and mechanical properties and durability are qualities that determine its value. Placing in position: correct setting, suitable mortar, anchorage or other means to maintain secure placement...and other things that help to retain the original value of the material.

—The Chicago Department of Buildings¹²³

In 1923, two sets of specifications for terra cotta were published. The first were “Setting Specifications” written by the Chicago Department of Buildings.¹²⁴ The second were the all-inclusive “Standard Specifications” written and adopted by the National Terra Cotta Society.¹²⁵ In the first set, the Chicago Department of Buildings investigated the elements of successful terra cotta installation. In their minds, “However good the material

¹²² Society, *Architectural Terra Cotta: Standard Construction*, Forward.

¹²³ Chicago Department of Buildings Committee, “Setting Terra Cotta,” *The American Architect/The Architectural Review* 123, no. 2419 (1923): 425.

¹²⁴ *Ibid.*

¹²⁵ National Terra Cotta Society, *Standard Specification for the Manufacture, Furnishing, and Setting of Terra Cotta* (National Terra Cotta Society, New York, 1923). See also the journal *Pencil Points*, 1923.

may be, its usefulness and value may be depreciated or totally destroyed by improper installation.” The department created a committee, made up of terra cotta manufacturers from the Northwestern, the Midland, and the American Terra Cotta Companies and architects, engineers, to write a terra cotta specification with particular attention to installation. While the 1914 standards show iron anchors with some measurements, these specifications detail the type of material, the sizes, the protection, and the drainage of the anchoring systems. The wrought iron was required to meet the American Society for Testing Materials (ASTM) standards. Depending on the height of the course, the hanger thicknesses ranged from 1/2” to 3/4” in diameter while the dowels ranged from 5/8” to 7/8” in diameter. For the first time, it is suggested that the iron be “coated ...with asphaltum applied hot,” and encased in mortar to prevent corrosion. Further protection of the anchorage is suggested through proper pointing with sufficient mortar of a 3:1 mixture of sand to Portland cement with a 1:5 ratio of lime to cement.¹²⁶

Another important element to protecting anchorage is proper drainage of the blocks. Washes and drips were included in the 1914 standards which shed water from the decorative surface without running down the face of the block. The “Setting Specifications” introduced the practice of weep holes, or voids, placed in areas, “in which water is liable to accumulate, remain in the terra cotta after it has been backed up and bonded properly and all supporting iron has been encased.”¹²⁷ This phenomenon most often occurs on the inside corners of terra cotta blocks on the cornice or soffit.

¹²⁶ Committee, “Setting Terra Cotta,” 426.

¹²⁷ Ibid.

The “Standard Specifications” combined the division of labor as set forth by Warren in 1905 and the setting procedures as outlined by the Chicago Department of Buildings into one definitive set of specifications. It further defined the terra cotta manufacturer’s responsibilities, anchor sizes and fitting, and techniques for the protection of supporting metal work. The manufacturer, while not responsible to supply the iron, was required to draw up an anchor schedule detailing all necessary metal supports for the terra cotta. This was one of the many required drawings to be submitted to the architect as specified. Additionally, the specifications outlined methods of the architect’s approval for models and surface finish including photography and samples. Further definitions of the manufacturer’s responsibilities were included as “Suggestions for Corollary Clauses” at the end of the specifications to cover project-specific conditions.¹²⁸

The instructions under the subheading “Supporting Metal Work and Anchors” of section E-Erection, defines metal work for terra cotta in terms of two framing technologies: structural steel and structural concrete.¹²⁹ Echoing the labor divisions set out by Warren in 1905, these specifications indicate the mason is responsible for supplying all non-structural metals for securing the terra cotta including: anchors, hangers, bolts, clips, straps, rods, and pins. With concrete construction, however, the contractor for structural concrete is required to supply and set all supporting metal work imbedded in the concrete and all shelf angles and continuous rods. With an additional contractor to work with, these specifications set out to standardize the sizes of all metal terra cotta supports:¹³⁰

¹²⁸ Society, Standard Specification for the Manufacture, Furnishing, and Setting of Terra Cotta 11.

¹²⁹ Ibid.3.

¹³⁰ Ibid.4.

- *Anchors:*
 - *For ashlar or courses balanced on the wall:* shall be 1/4" x 1/4," or 1/8" x 5/8," or No. 6 gauge galvanized wire.
 - *For projecting courses not balanced on the wall:* shall be not less than 5/8" round or square bars of equal cross section
- *Hangers:* shall be 5/8" diameter round bars or other shapes of equal cross section area.
- *Clips and Straps:* shall be 3/8" x 2"
- *Pins:* shall be 1/2" diameter round bars
- *Continuous Rods on concrete wall faces to which Terra Cotta ashlar is clipped:* shall be 5/8" diameter round bars which shall be secured to the masonry with 1/2" diameter round anchors placed not more than 2' on centers.

These dimensions determined the size of anchor holes fabricated in the terra cotta blocks as well as the surface area of potential deterioration due to exposure to water.

The NTCS specifications, revealing other advances in technology, indicated for the first time that metal supports shall be of wrought iron or non-corroding soft steel. Similar to the "Setting Specifications," there is a section devoted to the protection of the metal pieces against corrosion recommending asphaltum applied hot and mortar encasements.¹³¹ But these specifications take protection one step further by recommending "two coats of pure red lead and linseed oil paint...or other protective compound." Corroding metal supports affected the durability of the terra cotta construction and were a source of concern for the manufacturers.¹³²

Beyond technological advances and disputes over the division of labor, the standards and specifications for terra cotta were integral to overcoming inconsistencies within the material itself. Warping, shifting colors and anchorage failures prevented many architects from utilizing terra cotta in their project specifications. Parameters and tests for

¹³¹ Ibid.

¹³² See "Metal Coatings" in this report page 61.

physical properties were excluded from terra cotta specifications as the industry did not have a full grasp on scientific knowledge of their material. Eskesen, treasurer of the NTCS, explained:

The problems which troubled us years ago are still troubling us. Conditions are constantly changing, and so today, as it was yesterday, the question is, if we must eliminate defects and failures, to adapt our material to the changed conditions. It is among others a question of proper construction; it is also an engineering question; a question of how to build so as to protect our product from the ravages of moisture and changing climate.¹³³

To address the failures of the material in manufacture, the industry attempted to standardize the quality of the output at the plant. This was done in conjunction with the Bureau of Standards but the results were never made publicly available before the era of terra cotta ended in the 1930s and 1940s. To address the failures of the material in construction, the National Terra Cotta Society planned to produce a revised edition of the 1914 standards that included research from the Bureau of Standards as well as methods of accepted practice from the manufacturers.

In 1926, the new NTCS Director of Engineering, Robert Smith Johnston, focused his efforts on improving the structural failures resulting from connections between terra cotta and the flexible steel frame. He concluded, "Failures of this type are based on the accumulation of excessive loads from what appears to be improper support, lack of allowance for thermal changes (expansion and contraction) and excessive strains from the flecture of beams, girders, lintels, etc." As a response, he claimed the engineering division must keep in mind the following guidelines when drawing the setting designs:

- Proper and economical block form
- Proper methods of anchorage

¹³³ Eskesen, "The Investigation of Terra Cotta Work at the Bureau of Standards," 160.

- Proper shelf supports
- Proper allowance for thermal expansion and contraction
- Proper allowance, in concrete buildings, for changes in length of the structure from shrinkage in hardening or expansion from the absorption of moisture
- Deflection of the beams and columns of the structural frame and flexure of the building as a whole
- The protection of the terra cotta from infiltrated water
- The protection of the anchorage and structural frame from corrosion
- The security of the construction as a whole
- The economy of the construction

Though never printed, these principles were to be integrated into a series of simple plates that clearly outlined the construction practices for particular architectural elements in a publication called “The Principles of Terra Cotta Construction.” Some of the new ideas included: non-corrosive anchorage to prevent failures due to water exposure; unfilled terra cotta blocks to increase flexibility in construction to adjust to temperature changes and load deflection; and elastic expansion joints to allow for thermal expansion and contraction and prevent cracking.¹³⁴

These findings met mixed reviews with the members of the National Terra Cotta Society. The manufacturers resisted including structural steel information in their shop drawings as they felt it was out of their realm of expertise and a hardship. To this notion Johnston replied:

The principles on which we base secure construction should be developed. If we show what we consider essential we are far more likely to secure what we desire than if we neglect to do so, on the basis that it can be taken care of later. If we have something to show we can educate the user to its desirability and acceptance. If we fail to show the type of support we feel is essential, we lose the initial opportunity of incorporating it as one of our fundamentals of practice. We believe in cases like

¹³⁴ Robert Smith Johnston, *Principles of Terra Cotta Construction* (National Terra Cotta Society, New York, 1926). This is taken from an excerpt in Johnston’s report that is photocopied in the Papers of the National Terra Cotta Society located at Carey and Company Architects, San Francisco, California. It has been reproduced in Fus, “Architectural Terra Cotta: Standards, Specifications, and Testing”. Appendix C. Fus discusses Johnston’s contribution in his section on the National Terra Cotta Society on page 39 of his thesis.

this we should strive for security of construction even at the expense of having to educate the user to its advantages.¹³⁵

The Society also objected to the amount of expansion joints that Johnston recommended claiming that his testing regimen was not a reflection of standard practice. But Johnston emphatically declared the need for flexible construction and that expansion joints at the shelf angles, “must be quite frequent throughout the building height so that the straight section of ashlar between them are short enough to approximate the elastic curve of the deflection of the building frame.”¹³⁶ In his quest to standardize construction practices, Johnston collected sixty-nine sets of building codes from major cities across the country out of which only eleven included terra cotta specifically. It became clear that there were differing opinions on whether the blocks should be filled with mortar or not. This difference of opinion spread throughout the National Terra Cotta Society members impeding Johnston’s investigations and publication of his book.¹³⁷

Johnston’s work revealed the standards produced in 1914 were insufficient for modern construction. With his help, the National Terra Cotta Society published a revised edition of the standards in 1927 as a precursor to the publication of Johnston’s “Principles of Terra Cotta Construction.” These revisions incorporated improved anchorage, proper shelf supports, expansion joints, water protection and drainage techniques, and unfilled blocks. The book contained 67 plates (three fewer than 1914) of detailed drawings, a

¹³⁵ Johnston, *Principles of Terra Cotta Construction* 31.

¹³⁶ *Ibid.* 19.

¹³⁷ Fus, "Architectural Terra Cotta: Standards, Specifications, and Testing", 39-51. Opinion of the National Terra Cotta Society was gleaned from the Minutes of the General Meetings and the Executive Committee Meetings as recorded by F.S. Laurence. These minutes are photocopied in the Papers of the National Terra Cotta Society, Carey and Company Architects, San Francisco, California.

synopsis on the manufacturing of terra cotta, a glossary of related terms, and standard and short form specifications.

However, as indicated in the prevalent difference of opinion within the industry on construction practices at that time, there was still little known information on the physical and mechanical properties of the material despite ongoing tests at the National Bureau of Standards. Yet, in *The Summary of the Printed Reports 1-8 on the Technical Work of the Society* from 1922, proposed specifications were included for transverse strength, absorption, freezing tests, and compressive strength. The transverse strength specification, to be used instead of crushing strength, suggested a minimum modulus of rupture requirement at 1,000 to 1,600 lbs. Tentatively, 11.5 percent maximum absorption was recommended for terra cotta. To measure freezing resistance, a satisfactory resistance to a Sodium Sulphate artificial freezing test was also tentatively recommended. For compressive strength, a requirement of 2500 lbs per square inch minimum average on two inch sample cubes was recommended.¹³⁸ The Society did not feel confident about these tentative tests and omitted such parameters for quality testing in their 1927 revision of *Standard Construction*. The specifications, unchanged from 1923, still included the statement:

In view of the researches now being conducted by the National Bureau of Standards at the instance of the National Terra Cotta Society, it seems inadvisable to attempt, at this time, to write either quality clauses in terms of crushing strengths, densities, and elasticity, or specifications for tests.¹³⁹

¹³⁸ The National Terra Cotta Society Fellowship, *Summary of the Printed Reports 1-8 and the Technical Work of the Society* (National Bureau of Standards, Washington DC, 1922), 16. .

¹³⁹ National Terra Cotta Society, *Terra Cotta: Standard Construction* (New York: National Terra Cotta Society, 1927).

Just at the point when the Bureau of Standards was beginning to make progress with their tests, the Terra Cotta industry went into decline. By the end of the 1920s, the terra cotta industry was faced with steep competition from new building materials causing budget problems for individual plants and consequently for the NTCS. Due to this business atmosphere in combination with the national depression after the stock market crash of 1929, The National Terra Cotta Society could no longer afford to produce publications. Johnston's project was abandoned and the 1927 Standards, supposedly the precursor to a comprehensive technical manual, became the most complete source for information on terra cotta ever published.

LATER SPECIFICATIONS

The terra cotta industry has given serious thought to all of the difficulties which may arise after the material has been erected in the building in order to try to eliminate later trouble, due either to improper use of the material or its improper erection and construction in the building.

—E. V. Eskesen¹⁴⁰

The 1940 specifications written by Harold Reeve Sleeper, co-author of the *Architectural Graphic Standards*, included information on expansion joints, anchorage, and water protection. Recognizing the work started by Robert Smith Johnston in 1926, Sleeper integrated, "requirements for caulking compounds that were elastic, waterproof, and had good adhesion qualities" to be used for flexible construction.¹⁴¹ To prevent corrosion of the anchors, stainless steel was offered as a viable material for the first time. Two anchors became required for all ashlar pieces whereas previously it was assumed that anchors might

¹⁴⁰ E.V. Eskesen, "Watertight Terra Cotta Construction," *ACS Journal* 13 (1934).

¹⁴¹ Fus, "Architectural Terra Cotta: Standards, Specifications, and Testing", 95.

not even be necessary. Ventilating holes, to allow moisture to escape, were required to supplement weep holes and protect both the terra cotta block and its anchors. Sleeper incorporated the seepage bar joint, patented by the Federal Seaboard Terra Cotta Corporation in 1932, as an additional method of water protection. This method installs a non-corroding metal such as zinc or copper into pre-cut grooves at the joint between two blocks so that it is, “positively spanning and sealing the mortar joints and directing the seepage, if any, to the place where it will do the least damage.”¹⁴² The 1940 specifications also hold significance as they finally incorporated testing data from the National Bureau of Standards. Quality tests were specified for the detection of resistance to cracking, crazing, peeling, and spalling. Tests for imperviousness, opacity, and acid resistance were additional options to determine the quality of the material.¹⁴³

In Susan Tindall’s article, “How to Prepare Project-Specific Terra Cotta Specifications,” she concludes:

The last specifications published for terra cotta were geared toward ceramic veneer...The one change in this final specification which most clearly typifies the evolving nature of the industry is the total absence of any specification for submittal of models to the architect prior to manufacture. Terra cotta had ceased to be an idiosyncratic material and had become standardized.¹⁴⁴

Standards and specifications for terra cotta evolved out of a need for inter-disciplinary cooperation within new building technologies. The terra cotta manufacturers wanted to prove the merits of their material by securing the fundamentals of construction across all involved fields to ensure the durability of their product. To this end, the standards and specifications were the means to avoiding costly on-site adjustments, defining the

¹⁴² Eskesen, "Watertight Terra Cotta Construction," 160.

¹⁴³ Fus, "Architectural Terra Cotta: Standards, Specifications, and Testing".

responsibilities of each sub-contractor, disseminating accepted installation practices, and ensuring structural integrity.

METAL COATINGS

“The rusting of iron, the most familiar example of metallic corrosion, has been associated since Biblical times with corruption of the treasures of the earth.”

—R. M. Burns¹⁴⁵

To ensure the new technology of iron frame construction would be durable over time, it was understood that the metal had to be protected against corrosion. One of the first mentions of protecting the iron work occurs in the 1905 specifications written by Warren. He indicated, “The anchors or rods used for fastening the terra cotta should be wrought iron painted or galvanized to protect them from rust...”¹⁴⁶ Rust is a reddish-brown and crumbly corrosion product that occurs when iron is exposed to moisture and oxygen. When this exposure occurs inconsistently, the surface is characterized by small crevices that allow the rust to penetrate deep into the material.¹⁴⁷ To prevent this weakening of the iron a common solution was to use paint as a sacrificial protective layer. For example, “A judiciously chosen film of paint, applied under the best conditions to suit the particular needs of the situation in which the structure is exposed, may lengthen the

¹⁴⁴ Tindall, “How to Prepare Project Specific Terra Cotta Specifications,” 32.

¹⁴⁵ R. M. Burns and W. W. Bradley, *Protective Coating for Metals*, ed. F. Marshall Beringer, 3rd ed., *American Chemical Society Monograph Series* (New York: Reinhold Publishing Corporation, 1967), 1.

¹⁴⁶ Warren, “Notes on the Standard Form of Specifications for Architectural Terra Cotta,” 9.

¹⁴⁷ L. Reed Brantley and Ruth T. Brantley, *Building Materials Technology* (New York: McGraw Hill, 1996), 147-53.

effective life of the metal many times.”¹⁴⁸ The best protection from paint depends on its adherence to the material, its impermeability, and the corrosive properties of its pigments. In the early twentieth century, lead paint was seen as the best coating for iron.¹⁴⁹

Galvanized iron refers to a zinc coating over iron that is more corrosion resistant and functions as a sacrificial layer to prevent premature deterioration of the iron.¹⁵⁰ In the early twentieth century, iron was often galvanized through hot-dipping. This process consists of “dipping the article to be coated in a bath of molten metal and after a sufficient time removing it with its adherent film of metal.”¹⁵¹ While this process continues today to be used to coat large surfaces, it is difficult to regulate the thicknesses of the coatings.

In the 1923 specifications, it was recommended to protect the supporting metal work with lead paint or asphaltum applied hot. Asphalt is an organic compound that has been used in construction as early as 3600 B.C.¹⁵² The benefit of an organic compound coating is that “organic coatings protect metals by virtue of the interposition of a continuous, inert, and adherent film between the surface of the metal and its environment.”¹⁵³ This is different from a metal coating in that metallic finishes depend on “electrochemical relationships between the environment, coating, and base metal” for

¹⁴⁸ Ernest S. Hedges, *Protective Films on Metals*, ed. E. Howard Tripp, 2nd ed., vol. 5, *A Series of Monographs on Applied Chemistry* (New York: D. Van Nostrand Company, Inc., 1937), 365.

¹⁴⁹ *Ibid.*, 367-74.

¹⁵⁰ Brantley and Brantley, *Building Materials Technology*, 159.

¹⁵¹ Hedges, *Protective Films on Metals*, 233.

¹⁵² Burns and Bradley, *Protective Coating for Metals*, 419.

¹⁵³ *Ibid.*, 377.

effective protection.¹⁵⁴ Asphalt is usually applied hot to metals in thick coatings to provide the best protection.

After 1923, there were a series of specifications published that continued to define the manufacturer's responsibilities and organize the material in a concise manner. Few additions were made to anchorage hardware in 1929 and 1940 but some new recommendations were made for metal protection. The 1929 specifications, copyrighted by the New York Building Congress, introduced new methods of protecting metal supports for terra cotta.¹⁵⁵ These included udylliting the iron or steel and also substituting bronze for iron or steel. Udylliting refers to a thin coat of cadmium electroplated to iron.¹⁵⁶ Cadmium is considered to be competitive with zinc as a coating material for iron which both act as barriers to the electrochemical corrosion of iron. Its advantages include less corrosion products and better aesthetic appearance. Its disadvantages include pinhole corrosion of the iron through pores in the coating.¹⁵⁷ Electroplating involves the transfer of metallic ions instigated by an electric current from one positively charged material to another negatively charged material.¹⁵⁸ When it first became popular in commercial construction the cadmium carbonate, the anode, was dissolved in a solution of sodium cyanide, the

¹⁵⁴ Ibid.

¹⁵⁵ There were two specifications published in *The American Architect*, one titled "Manufacture and Furnishing of Terra Cotta" in the June 5, 1929 issue, and the other titled "Setting of Terra Cotta" in the June 20, 1929 issue. Both of these relied heavily on previous specifications and incorporated only slight changes.

¹⁵⁶ Fus, "Architectural Terra Cotta: Standards, Specifications, and Testing", 91.

¹⁵⁷ Burns and Bradley, *Protective Coating for Metals*, 172.

¹⁵⁸ Ibid., 76.

cathode.¹⁵⁹ Electrodeposited coatings are characteristically more uniform than hot-dipped coatings and have a purer concentration of the metal.¹⁶⁰

The substitution of iron with more durable metals was used, especially for anchors, to circumvent corrosion problems. Bronze, for example, is a copper and tin alloy that is high in strength and hardness and is corrosive resistant.¹⁶¹ In the 1940s specifications, Stainless steel was suggested as an appropriate anchor material. It is an iron and chromium alloy that is highly corrosion resistant, low-maintenance, and extrudable. While stainless steel was introduced in America in 1916 but it was not widely used until the 1940s.¹⁶² Today, stainless steel is commonly specified for anchor material. For example, the Boston Valley Terra Cotta Company produced a revision of the NTSC 1927 standards and specifications in 1997. In section E-Installation under “Supporting Metal Work and Anchors” they specify that anchors shall be of stainless steel or galvanized steel.¹⁶³

¹⁵⁹ Ibid., 173.

¹⁶⁰ Ibid., 75.

¹⁶¹ Dr. Agnes Segal, *Copper Alloys- Bronzes* (AZoM.com, 2002 [cited April 13, 2003]); available from <http://metals.about.com/gi/dynamic/offsite.htm?site=http%3A%2F%2Fwww.azom.com>.

¹⁶² Thomas C. Jester, *Twentieth Century Building Materials: History and Conservation* (Washington, DC: McGraw-Hill Companies, 1995), 64-71.

¹⁶³ Boston Valley Terra Cotta Company, *Architectural Terra Cotta- Standard Construction* (Boston Valley Terra Cotta Company, Orchard Park, New York, 1997),

CHAPTER 4 : ANCHORS AND HANGING SYSTEMS

After establishing manufacturing processes, business organization, and product development, it is important to understand how these components of the terra cotta industry were put into practice. The National Terra Cotta Standards were a comprehensive attempt to regulate installation practices of all the terra cotta companies, but how well were they adhered to? Was there a visible shift in the company shop drawings that reflects the move toward standardization? Did the manufacturers continue to develop new techniques despite the collective effort to streamline the installation systems? To answer these questions, the following section compares the suggested techniques from *Architectural Terra Cotta: Standard Construction* (1914 and 1927) with shop drawings from the Northwestern Terra Cotta Company and the O. W. Ketcham Terra Cotta Works.

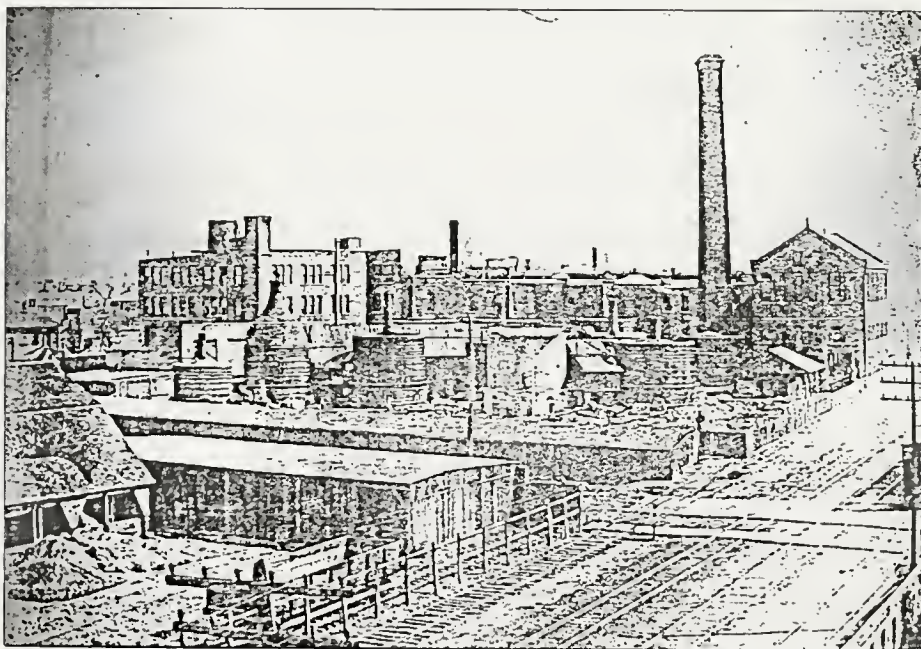


Figure 8: A Northwestern Terra Cotta Company manufacturing plant. Image found in the vertical files of the Northwestern Collection at the National Building Museum.

Shop drawings for the Northwestern Terra Cotta Company are located in the archives of the National Building Museum in Washington, D.C. Edward J. Mertes of Mertes Contracting Corporation in Chicago, Illinois, rescued the drawings from the site of the defunct Northwestern Terra Cotta Co. in Denver, Colorado, before major floods destroyed the building in 1964. He loaned over 51,000 drawings dating from 1900 to 1954 to the National Building Museum. This report includes twelve selections from the archives that specifically contained anchor schedules dating from 1900 to 1915. These projects provide clues to company installation techniques prior to and just after the 1914 standards produced by the National Terra Cotta Society. The twelve selected buildings include:

1. Stewart Brothers Building, Buffalo, New York. Green and Wicks, 1900
2. U.S. Post Office and Court House, Greenville, Tennessee. Jas. K. Taylor, 1903
3. Eye and Ear Hospital, Pittsburg, Pennsylvania. MacClure and Spahr, 1903
4. Fourth National Bank Building, Cincinnati, Ohio. DH Burnham and Co., 1905
5. Hotel Grunewald, New Orleans, Louisiana. H.C. Kock and Son, Toledano and Wogan, 1907
6. Chemistry Building, University of Washington, Seattle, Washington. Howard and Galloway, 1908
7. People's Gas Light and Coke Co., Chicago, Illinois. D.H. Burnham and Co., 1909
8. City Hall, Chicago, Illinois. Holabird and Roche, 1909
9. Clay County Courthouse, Vermillion, South Dakota. Lloyd D. Willis, 1912
10. Curry Building, Winnipeg, Canada. J. D. Atchison and Co., 1915
11. Masonic Temple Building, Atchison, Kansas. Crumpacker and Wyatt, 1915.
12. Le Moyne Public School, Chicago, Illinois. A. F. Hussander, 1915.

As a large manufacturer, the Northwestern Terra Cotta Company had a major impact on developments within the industry. In 1877, John R. True, Gustav Hottinger, and John Brunkhorst left the Chicago Terra Cotta Co. to establish True, Brunkhorst and Company. Sanford E. Loring of the Chicago Terra Cotta Works, went out of business and leased the Chicago Terra Cotta plant at W. 15th and Laflin Streets in Chicago in 1880 to

this new company now calling itself “Northwestern.” By 1883, a new factory was constructed on the corner of Clyborne Ave, and Wrightwood Ave in Lake View with four large kilns.¹⁶⁴ The company experienced measured success as evidenced in an 1886 article in *The Inland Architect and Builder* that featured twenty-five buildings with Northwestern terra cotta. In the article, the company claims:

“The demand for our red and brown semi-glazed terra cotta is such this year that we were obliged to buy the works on corner West 15th and Laflin Streets (the old Chicago Terra Cotta Works), and build two new kilns at our works on corner Clyborne and Wrightwood Avenues, giving us in all fourteen kilns, and enabling us to supply our clients with usual promptness.”¹⁶⁵

The company was incorporated in 1888 as the Northwestern Terra Cotta Company¹⁶⁶ and by 1913, it reported to the National Terra Cotta Society \$1,133,201 in total net contracts, more than any other member of the Society by hundreds of thousands of dollars.¹⁶⁷ By 1927, Northwestern was the largest terra cotta manufacturer in the United States with main offices in Lake View, Illinois, and branches in Denver, St. Louis, and Chicago Heights. At its prime, the company employed 650 persons.¹⁶⁸

¹⁶⁴ Sharon S. Darling, “The Northwestern Terra Cotta Works,” *Chicago Ceramics and Glass*: 168-69. Photocopied in the vertical files of the National Building Museum.

¹⁶⁵ *The Inland Architect and Builder* 7, no. 11 (1886): 97.

¹⁶⁶ Geer, *The Story of Terra Cotta*, 181.

¹⁶⁷ Comparative Recapitulation Sheet: Reports of Orders (National Terra Cotta Society, New York, 1913), From the New York Architectural Terra Cotta Company Collection at the Avery Archives, Columbia University. Box 167, folder 4.

¹⁶⁸ Vertical Files of the National Building Museum.



Figure 9: The O.W. Ketcham factory in Crum Lynne, Pennsylvania. Image found in the Ketcham Collection at the Athenaeum of Philadelphia.

An additional source of information for this section of the report is the O. W. Ketcham Collection located at the Athenaeum of Philadelphia. This collection holds over 980 records including shop drawings and photographs dating from 1889 to 1995. The collection was donated by the Ketcham family to the Athenaeum when the company closed its doors in 1995. This report analyzes ten projects with anchor schedules that date from 1926-1931. These projects provide clues to company installation techniques after the publication of the standards produced by the National Terra Cotta Society in 1927. When compared to the published standards from 1914 and 1927 as well as the shop drawings of the Northwestern Terra Cotta Company, it is revealed that Ketcham never stopped pushing the limits of terra cotta innovation. The ten buildings include:

1. The Oliver Cromwell Apartment Hotel, New York, New York. Emery Roth, 1926-27
2. Physicians Building, Newark, New Jersey. William E. Lehman, 1927
3. First National Bank, Philadelphia, Pennsylvania. Ritter and Shay, 1927
4. Navy Central YMCA Annex, Philadelphia, Pennsylvania. Louis E. Jallade, 1928

5. West Side YMCA and Addition, New York, New York. Dwight James Baum, 1929-1930
6. Aldine Trust, Philadelphia, Pennsylvania. Arthur W. Hall, 1929.
7. Temple Israel, Lawrence, Long Island, New York. S. Brian Boylinson, 1930
8. Mother House, Sisters of Christian Charity, Mendham, New Jersey. Robert J. Reiley, 1930-31
9. Market Street National Bank, Philadelphia, Pennsylvania. Ritter and Shay, 1930
10. Redemptorist Father's Community House, Washington, DC. Anthony F. A. Schmitt, 1932

The O.W. Ketcham Terra Cotta Works was one of the smaller manufacturers but it was well known for its vibrant glazing. Ketcham began his career as a building materials distributor for such firms as Boston Terra Cotta, Fiske, Homes and Co., the Grueby Faience Company, the Excelsior Terra Cotta Company, and the Pennsylvania Enameled Brick Company. In 1895, he opened the O. W. Ketcham sales office in the Philadelphia Builder's Exchange.¹⁶⁹ Through his dealings, he realized that there was more demand for terra cotta than there were suppliers. In 1906, he opened his own plant in Crum Lynne, located southwest of Philadelphia on the Pennsylvania Railroad. He hired ceramicist William Stephani, and together they, "developed glazing techniques that later became identifying characteristics of the Ketcham plant's highly regarded polychrome work."¹⁷⁰ The clay body of the Ketcham Company consisted of approximately 33% grog from Western Pennsylvania or Ohio, 20% Darlington Clay from Western Pennsylvania, 30% Perrines Clay from Perth Amboy, NY, and 17% from Maryland including Campbell Dark Red for red body.¹⁷¹

¹⁶⁹ "Philadelphia," *The Brickbuilder* 4, no. 9 (1895): 199.

¹⁷⁰ Barton, "O. W. Ketcham Terra Cotta: Reflections on an Industry in Chaos after World War Two," 12.

¹⁷¹ *Ibid.*: 13.

In 1913, seven years after its inception, the company reported \$95,475 in contracts.¹⁷² The Ketcham Company was a founding member of the National Terra Cotta Society and participated in the joint efforts of the organization to promote the industry. By the 1960s, however, the demand for architectural terra cotta was in sharp decline and the company was forced to rely on its brick and tile division. By 1995, sales were so low that the company closed its doors for good.

ANCHORS

The use of anchors contributed to the success of terra cotta construction in the early twentieth century. They secured blocks to each other as well as to the steel frame to create a unified skin for a building. With advanced understanding of the steel frame, engineers relied on anchors to compensate for thermal movement and load deflection in buildings. Anchors are defined as horizontal straps tie the piece of terra cotta to the body of the steel frame. The terra cotta is usually grooved at the top to hold the “J” or “Z” shape piece. The simplest of anchors includes the “Z” strap which was partially embedded in the back-up wall, either brick or concrete, and hooked into a recessed groove or hole in the terra cotta block.

¹⁷² Comparative Recapitulation Sheet: Reports of Orders (National Terra Cotta Society, New York, 1913)

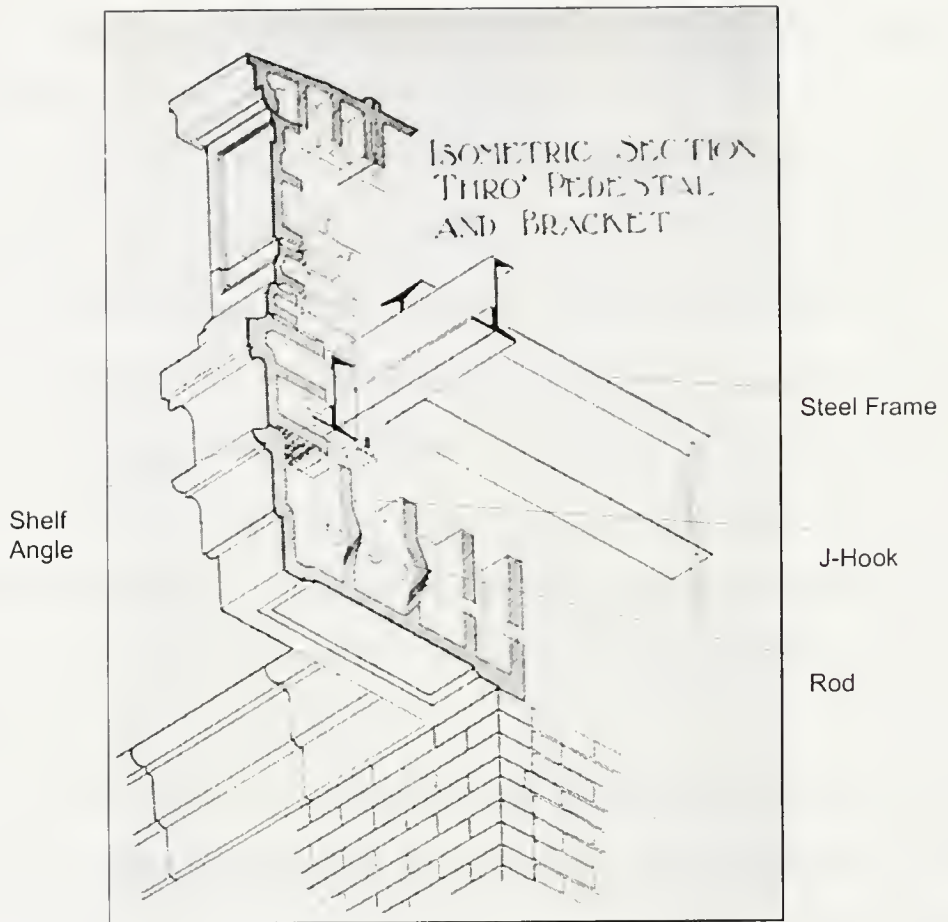


Figure 10: Isometric Drawing from a Northwestern Terra Cotta Company Trade Catalog (1906).

Hanging systems are a combination of horizontal anchors and vertical hangers, sometimes referred to as ‘belts and suspenders’, which secure the relationship of the blocks to each other as well as their relationship to the framing system. The typical metal hanger consists of a J-hook that has a grooved end which fits a bolt and a hooked end that connects around a rod or pin threaded through the webs of a block. The hanger is secured to a steel beam with the bolt and supports the terra cotta block with its hook. Hanging systems use

anchors and hangers in different configurations with the use of clips, clamps, plates, pins, and rods to secure the terra cotta block to the steel beams.

Of these pieces, the most versatile in terra cotta construction is the clip. It attaches to a steel member by overhanging one its flanges and provides a support base for a hanger. By bolting the hanger to the clip, the steel member does not have to be pierced and its structural integrity remains intact. The clip allows for adjustable construction which, at the time, was necessary to compensate for irregular dimension of the structural steel.¹⁷³ With further knowledge of the material in the 1920s, it became evident that adjustable construction was necessary for the material to withstand thermal changes and load variations. Clips proved indispensable at a time when steel framing plans and terra cotta installation plans did not always match.

Before standardization in 1914, manufacturers adjusted to the transition to the steel frame by implementing these complicated hanging systems. As discussed in chapter three, iron contractors and terra cotta contractors often operated independently at different phases of the construction process. Their lack of communication frequently called for an adjustment to either the framing plan or the design of the terra cotta pieces. The versatility of the hanging system configuration made such adjustments easier to implement. Thomas Cusack elucidates such a situation in lintel construction in a *Brickbuilder* article from 1898.

¹⁷³ Society, *Architectural Terra Cotta: Standard Construction*, 70.

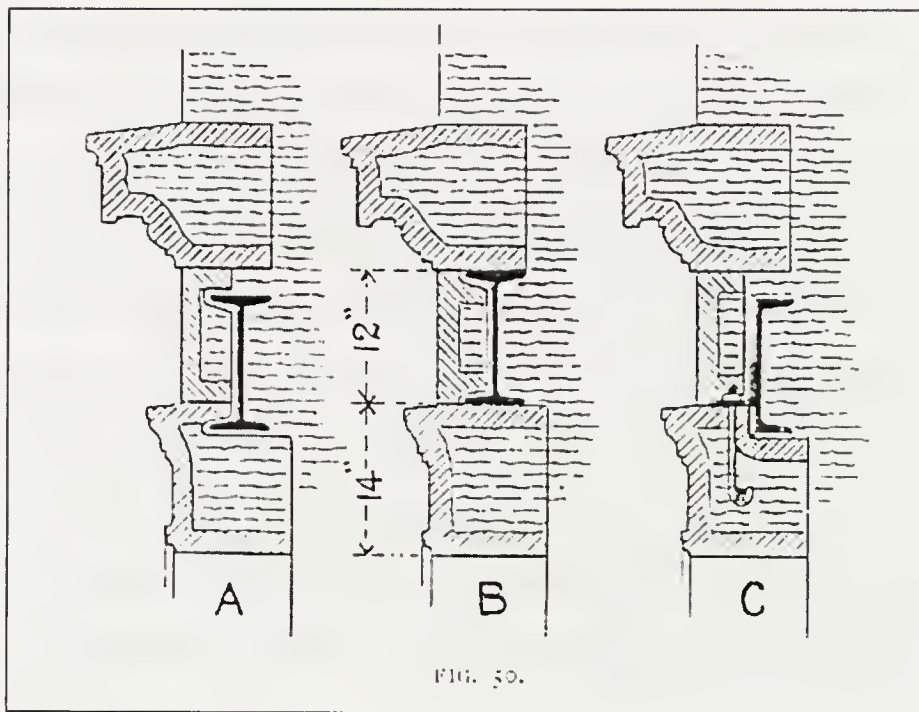


Figure 11: Three iron beam installation variations from *The Brickbuilder* (1898). Notice the different shapes of the terra cotta blocks made to fit the iron beams.

Drawing A illustrates an arbitrary placement of the I-beam at the lintel. This configuration requires cutting the back edge of the terra cotta block to receive the beam, yet, reduces support of the lintel and the cornice above. Drawing B calls for adjusting the steel plan to raise the I-beam to directly support the cornice without weakening the blocks below. Drawing C illustrates how the terra cotta must be altered if the steel is required to stay in place. Cusack explains:

If, for any reason, the relative positions of I-beam and of lintel could not be altered, then a channel might be substituted, and on it an "L" riveted at any desired height, as at C. A lintel of this kind would be considered self-supporting up to 4', beyond which width of aperture it could be suspended by hangers, inserted in the manner indicated in section...

While a new piece of terra cotta must be manufactured to fit the I-beam, the anchor configuration ensures strength and durability to an otherwise objectionable design. These hanging systems varied from manufacturer to manufacturer according to their experience and training. By 1914, however, The National Terra Cotta Society attempted to collect the best and most widely used examples of anchors for their publication *Architectural Terra Cotta: Standard Construction*. Plate 70 arranged these details of anchors, hangers, straps, and clips into sixteen figures.¹⁷⁴ In 1927, the Society revised the standards to reflect research data compiled by their new engineering department. The section drawings changed dramatically with unfilled blocks, more anchors, and more steel supports. Additionally, weep holes and proper flashing techniques were to protect the material from water damage. Yet, the new version of the anchor details changed only slightly. Plate separators were introduced as a better way to brace the angles and steel members. Clips and clamps were turned around so that the flat sides of the pieces fully supported the units they were strengthening. These details illustrated in plate 67 were seen as the best way to increase flexibility in construction while securing the blocks to the steel or concrete frame.

¹⁷⁴ Ibid.

DETAILS OF IRON ANCHORS "HANGERS" "STRAPS" "CLIPS" "ETC"
USED IN SETTING ARCHITECTURAL TERRA COTTA

STRUCTURAL STEEL WHEN ERECTED FREQUENTLY VARIES FROM EXACT PLANNED DIMENSIONS. FOR THIS REASON ALL SUPPORTS FOR TERRA COTTA INCLUDING ANGLES "BUSH" "ANCHORS" "ETC" SHOULD BE DESIGNED SO AS TO EXEMPT OF EASY ADJUSTMENT TO THE NEARLY ALL REQUIREMENTS OF CONSTRUCTION WHEN THE MATERIAL IS BEING SET.

FIG. 1 1" ANCHOR SHOWN ONLY BE SET INTO THE MASONRY IN ALL OTHER INSTANCES IS FACTORABLE AS IT ALLOWS OF LITTLE OR NO ADJUSTMENT SEE PLS NO 3, 4, 5 AND 8.

FIG. 2 3" PINS AT JOINTS 3" SPACING TO CORNICE 3" 2" CLIP TO CHANNEL.

FIG. 3 3" 2" CLIP TO CHANNEL.

FIG. 4 3" 2" CLIP TO CHANNEL.

FIG. 5 1" ANCHOR SPACED TO 3" 2" ANCHORS.

FIG. 6 1" 2" CLIP TO CHANNEL.

FIG. 7 1" 2" CLIP TO CHANNEL.

FIG. 8 3" 2" CLIP TO CHANNEL.

FIG. 9 3" 2" CLIP TO CHANNEL.

FIG. 10 3" 2" CLIP TO CHANNEL.

FIG. 11 3" 2" CLIP TO CHANNEL.

FIG. 12 3" 2" CLIP TO CHANNEL.

FIG. 13 3" 2" CLIP TO CHANNEL.

FIG. 14 3" 2" CLIP TO CHANNEL.

FIG. 15 3" 2" CLIP TO CHANNEL.

FIG. 16 3" 2" CLIP TO CHANNEL.

FIG. 17 3" 2" CLIP TO CHANNEL.

FIG. 18 3" 2" CLIP TO CHANNEL.

FIG. 19 3" 2" CLIP TO CHANNEL.

FIG. 20 3" 2" CLIP TO CHANNEL.

FIG. 21 3" 2" CLIP TO CHANNEL.

FIG. 22 3" 2" CLIP TO CHANNEL.

FIG. 23 3" 2" CLIP TO CHANNEL.

FIG. 24 3" 2" CLIP TO CHANNEL.

FIG. 25 3" 2" CLIP TO CHANNEL.

FIG. 26 3" 2" CLIP TO CHANNEL.

FIG. 27 3" 2" CLIP TO CHANNEL.

FIG. 28 3" 2" CLIP TO CHANNEL.

FIG. 29 3" 2" CLIP TO CHANNEL.

FIG. 30 3" 2" CLIP TO CHANNEL.

FIG. 31 3" 2" CLIP TO CHANNEL.

FIG. 32 3" 2" CLIP TO CHANNEL.

FIG. 33 3" 2" CLIP TO CHANNEL.

FIG. 34 3" 2" CLIP TO CHANNEL.

FIG. 35 3" 2" CLIP TO CHANNEL.

FIG. 36 3" 2" CLIP TO CHANNEL.

FIG. 37 3" 2" CLIP TO CHANNEL.

FIG. 38 3" 2" CLIP TO CHANNEL.

FIG. 39 3" 2" CLIP TO CHANNEL.

FIG. 40 3" 2" CLIP TO CHANNEL.

FIG. 41 3" 2" CLIP TO CHANNEL.

FIG. 42 3" 2" CLIP TO CHANNEL.

FIG. 43 3" 2" CLIP TO CHANNEL.

FIG. 44 3" 2" CLIP TO CHANNEL.

FIG. 45 3" 2" CLIP TO CHANNEL.

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FIG. 154

DETAILS OF ANCHORS HANGERS STRAPS CLAMPS ETC. USED IN SETTING TERRA COTTA

STRUCTURAL STEEL WHEN ERECTED FREQUENTLY VARIES FROM EXACT FIGURED DIMENSIONS " " " FOR THIS REASON ALL SUPPORTS FOR TERRA COTTA INCLUDING ANGLES RIBS "ANCHORS" ETC. SHOULD BE DESIGNED SO AS TO PERMIT OF EASY ADJUSTMENT TO THE AVAILABLE REQUIREMENTS OF CONSTRUCTION WHEN THE MATERIAL IS DELIVERED

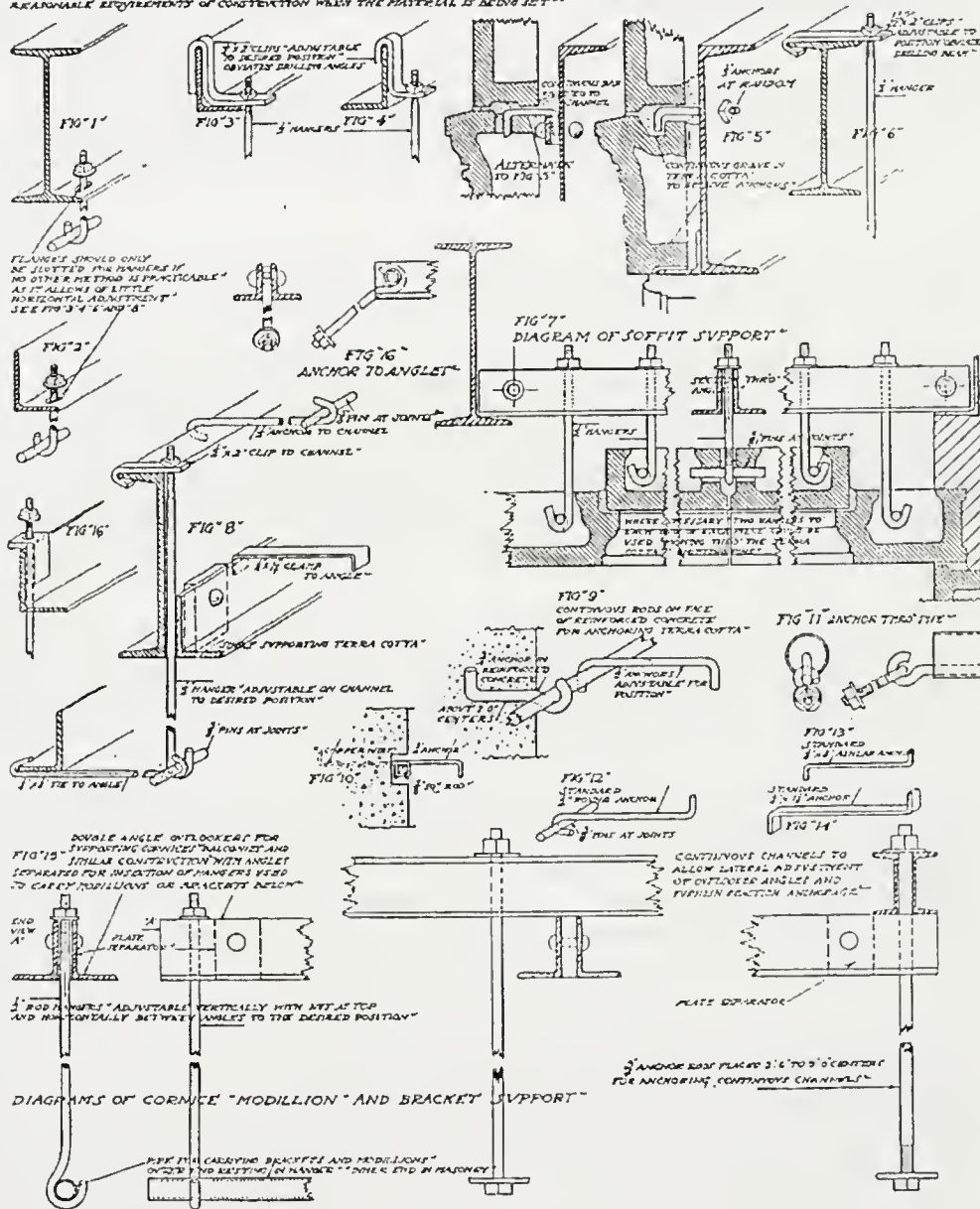


Figure 1: Shows a J-hook, or hanger, inserted into a slotted flange of an I-beam secured with a bolt and anchored by a rod. This configuration is only recommended when there is no other alternative as it does not allow for horizontal adjustment.

Figure 2: This is similar to figure one except that the J-hook is inserted into a slotted L-beam or angle.

Figure 3: This is a preferred alternative to slotting the steel member directly. 1/2" thick and 2" wide clips support a 1/2" in diameter J-hook while attached to the front an angle. The J-hook is secured to the clip by a bolt. This is a preferred configuration as it is adjustable.

Figure 4: This configuration is similar to figure three except that the clip is attached to the back of the angle.

Figure 5: While the first four examples show hanging configurations, figure five shows an anchoring configuration. An anchor that is 1/2" in diameter is inserted into a slot in the body of the I-beam and secured by a bolt. The other end is bent downward to connect to a groove in the top of the terra cotta piece. An alternative configuration is suggested which employs a continuous bar riveted to the outer side of the I-beam. A clamp is then used to connect the terra cotta block with the I-beam. Both of these configurations are not adjustable.

Figure 6: This is another alternative to figure five which uses a hanging system for adjustability. A 1/2" thick clip that is 2" wide is attached to the flange of the I-beam and supports a 1/2" hanger that is secured with a bolt.

Figure7: This hanging system is most often used for soffit construction. A Pin that is 5/8" thick in diameter is threaded through the joint of two pieces of terra cotta. Two angles are bolted together around 3/4" pipe separators. This allows enough space to thread through the angles multiple 1/2" diameter J-hooks which are secured to the top of the angles with a bolt. The J-hooks connect around the pins holding the terra cotta pieces in place. An alternative to this configuration is to omit the pins by hooking the J-hooks into holes in either end of the terra cotta blocks.

Figure 8 (1914): This is a complicated configuration that is most often used to support cornices, lintels, or soffits. The primary structural beam is C-beam, or channel, that is riveted to an angle with a 3/4" pipe separator. Threaded through the channel and angle is a J-hook that is supported by a clip similar to figure six. The J-hook supports terra cotta blocks that are pinned at the joints. The angle serves as a shelf joint to support the terra cotta blocks which are additionally anchored with clamps. Depending on the design, this configuration can support a number of other anchors for the terra cotta blocks.

Figure 8 (1927): A plate separator is used between the angle and the C-channel to provide attachment space for the clamp. The plate, or bar, separator gives full bearing to the metal unit and holds such pieces in line. The clamp is a bigger size a 1/4" x 1 1/4".

Figure 9: For concrete construction, anchors 3/4" in diameter are embedded approximately every 2' on center and threaded with a continuous rod. The terra cotta blocks are then secured to the building with 1/2" diameter clamps that connect to the rod and the recessed groove in the block. The clamps are adjustable.

Figure 10: An alternative for concrete construction employs embedded copper wire that wraps around 5/8" square rod. A 1/4" clamp is then used to secure the terra cotta blocks in the same fashion as figure nine.

Figure 11 (1914): This anchoring system is most often used for gargoyles. Two angles are riveted together with a 3/4" pipe separator to create an outrigger. A J-hook is connected to the outrigger by hooking around the bolt.

Figure 11 (1927): The outrigger configuration is changed to a pipe threaded with a J-hook to attach to the wall anchor.

Figure 12: This is the Standard Round Anchor that is 1/2" in diameter and hooks around 5/8" pins at joints.

Figure 13: This is the Standard Ashlar anchor commonly referred to as the "Z" strap. It is 1/4" wide and 1/4" thick.

Figure 14: This is a wider version of the "Z" strap that measures 1 1/4" wide and 1/4" thick.

Figure 15 (1914): This is a similar configuration to figure 7 but can be used for supporting modillions or brackets. Two angles are riveted together around 3/4" pipe separators to allow space for 1/2" diameter J-hooks. The J-hooks are adjustable vertically with the nut and bolt. They are also adjustable horizontally between the angles to desired positions. At the inner end of the angles, a C-channel, placed horizontally, holds down the double angles and is connected between the bolt of the J-hook and the angles.

Figure 15 (1927): The configuration is mostly the same in 1927 except the pipe separator is replaced with a plate separator. When a C-channel is used to brace the J-hook against the double angles, it should be placed vertically on both sides of the hanger. This arrangement holds the hanger in place as well as allows adjustment over time.

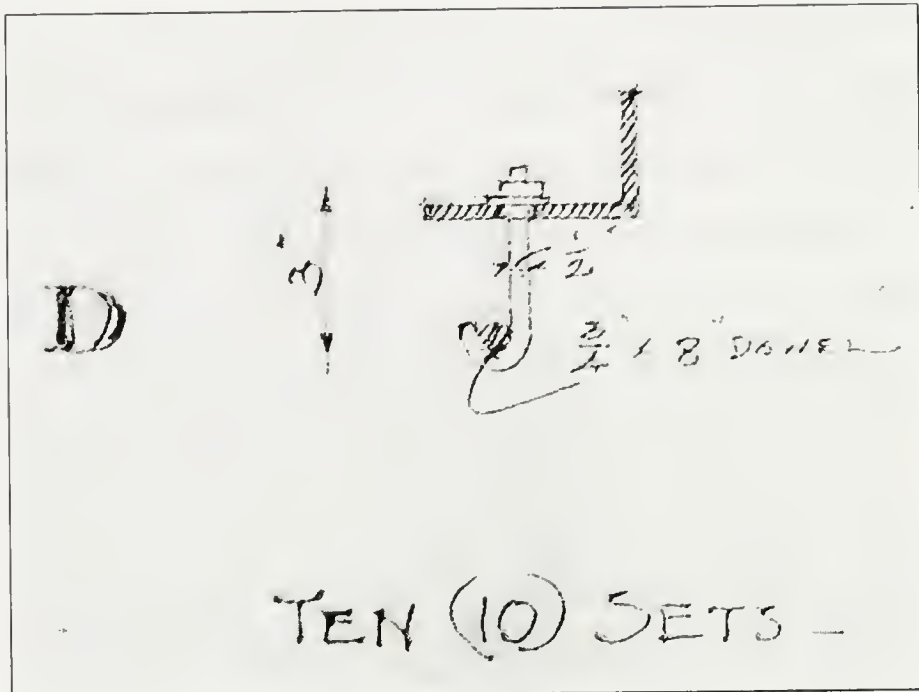
Figure 16 (1914): This piece is a trapezoidal shaped clip that attaches to the top flange of the angle. Its' wide top lip provides a support base for a J-hook.

Figure 16 (1927): The clip shape has been transformed from a trapezoid shape to an L-shape. This new shape provides maximum spacing and counteracts the twisting of the angles or hangers.¹⁷⁵

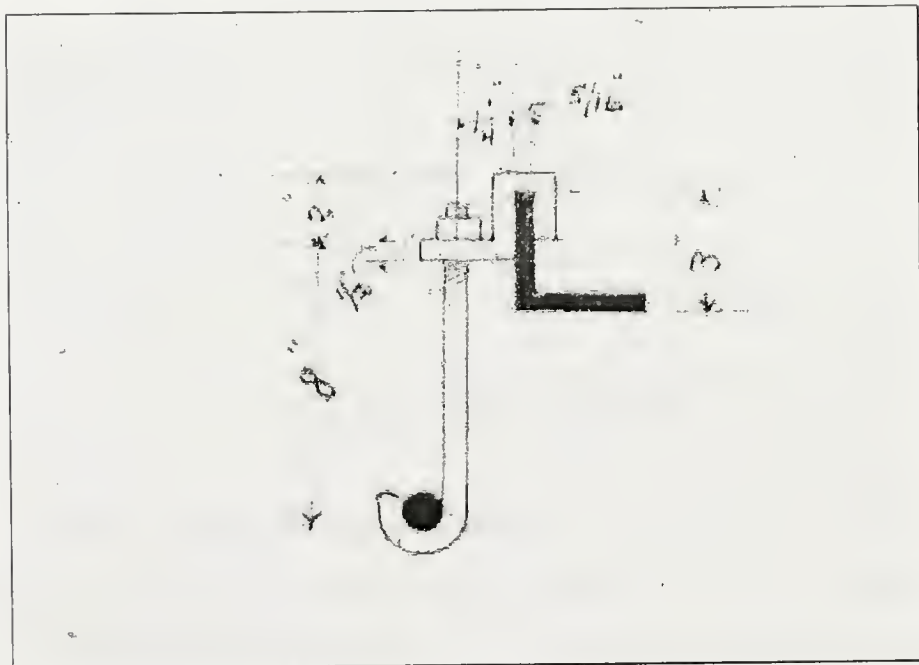
The Northwestern Terra Cotta Company was one of the largest manufacturers of terra cotta in the United States. As such, they were pioneers in terra cotta building technology. A survey of iron schedules from ten projects from 1903-1915 reveal that the configurations illustrated in the 1914 standards truly were a reflection of common practice. From the shop drawings examined, the Northwestern Terra Cotta Company often used configurations similar to Figures 2, 4, 6, 7, and 8. Sometimes these hanging systems were even used in tandem to provide extra support.

Yet, there are some differences between the standards and these early shop drawings. For example, the use of slotted steel beams seems to dominate the construction techniques whereas it is discouraged in the standards. The thicknesses of the anchors and hangers range from project to project. Most noticeably, the drawings also revealed different anchoring techniques not included in the 1914 standards.

¹⁷⁵ Tindall, "How to Prepare Project Specific Terra Cotta Specifications," 29. This information is taken from the Common Clay chart that Tindall included in her article.

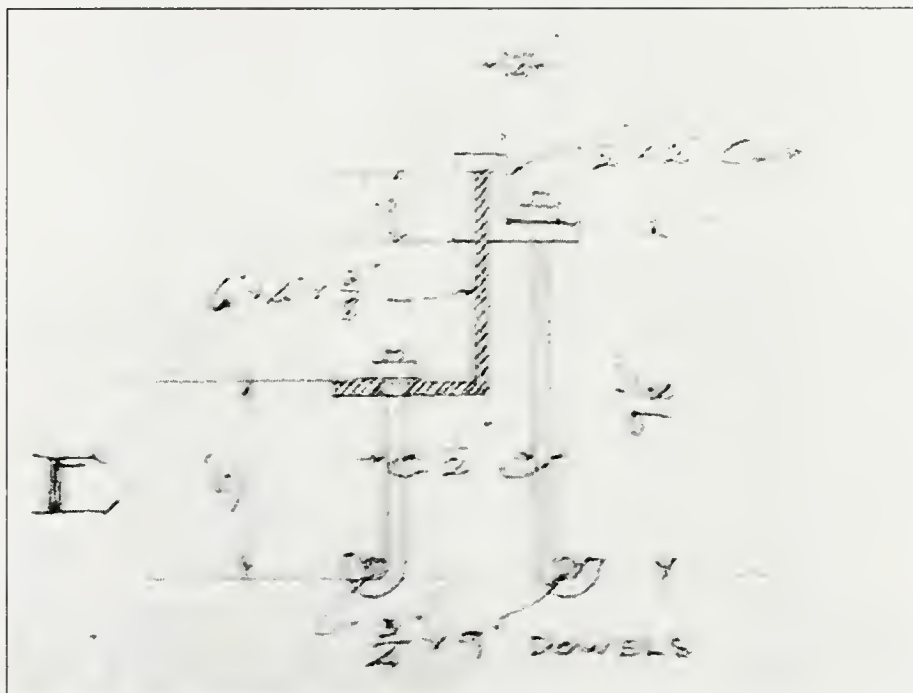


Example 1: Fourth National Bank (1905). The Northwestern Terra Cotta Company, Order 50/05, Drawing 54754, Draftsman: Gustafsmann.



Example 2: Hotel Grunewald (1907). The Northwestern Terra Cotta Company, Order 6367, Drawing 43176, Draftsman: J. A. Ohman

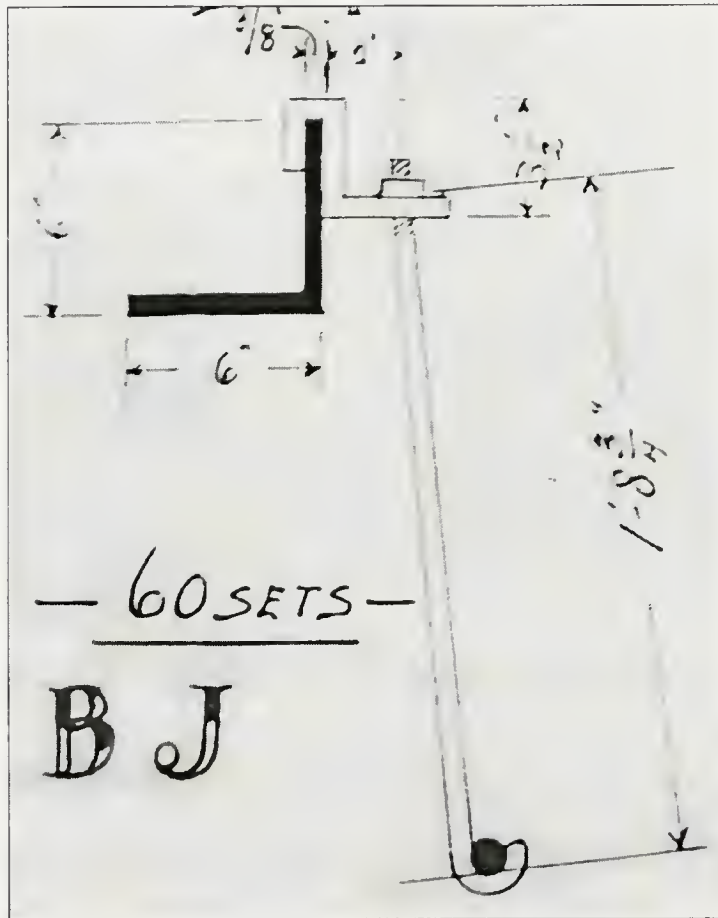
Example 1 shows a configuration similar to Figure 2 where the angle is slotted for the hanger. This example is taken from Fourth National Bank built in 1905. The J-hook is 1/2" in diameter but the dowel, or pin, is 3/4" in diameter which is thicker than the standard pin at 1/2" in diameter. Example 2 illustrates the use of Figure 4 from the Hotel Grunewald built in 1907. In this project, the clips are 1/2" thick and 2" wide just as in the standards. The hangers, however, range from 3/8" to 1/2" in the various configurations.



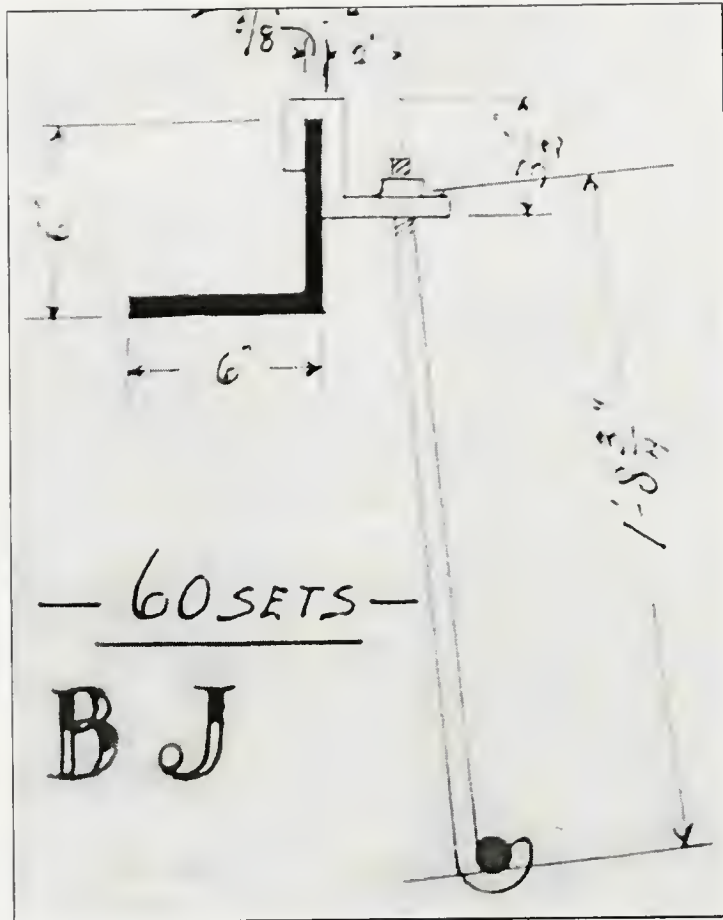
Example 3: Fourth National Bank (1905). The Northwestern Terra Cotta Company, Order 50/05.
Drawing 54754, Draftsman: Gustafsmann

This example taken from the Fourth National Bank built in 1905 shows how the different configurations were combined in common practice to provide more support. This is a combination of Figure 2 and Figure 4 that was used to support the spandrel. Just as in the standards, the hangers are 1/2" in diameter and the clips are 1/2" thick and 2" wide.

Again, the pins are 3/4" in diameter which is thicker than stipulated in the later standards. These drawings prove that the 1914 Standards did reflect the practices of the leading manufacturers but that there were many different ways to implement the basic patterns.



Example 4: Hotel Grunewald (1907). The Northwestern Terra Cotta Company, Order 6367, Drawing 43176, Draftsman: J. A. Ohman

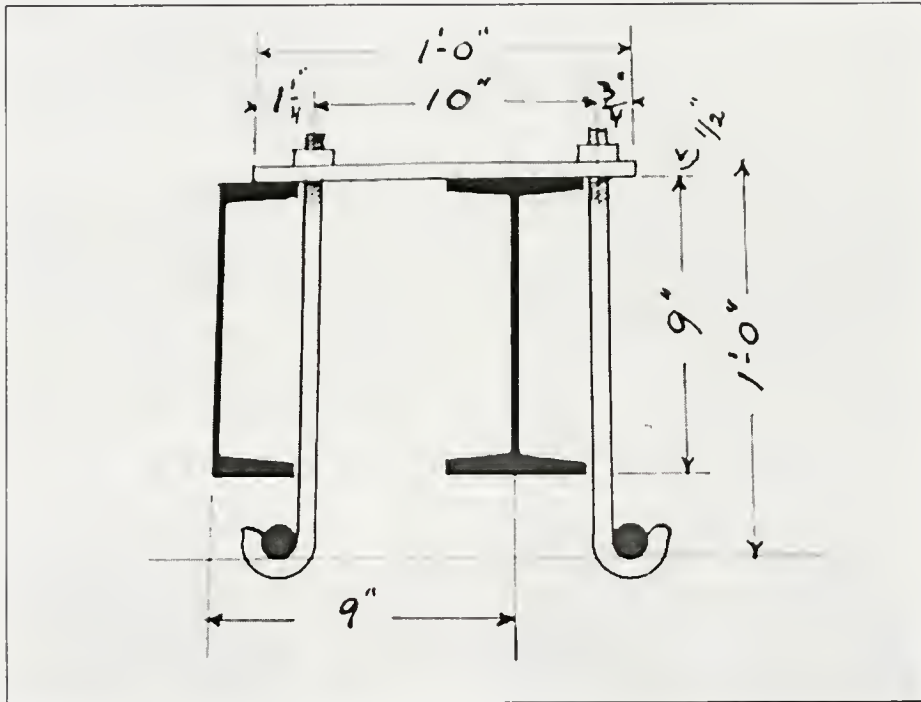


Example 5: Hotel Grunewald (1907). The Northwestern Terra Cotta Company, Order 6367, Drawing 43176, Draftsman: J. A. Ohman

Taken from the Hotel Grunewald from 1907, these examples show adaptations of Figures 6 and 4, respectively. Both configurations use clips for versatility of construction. By bending the hanger away from the steel beams, the hanging system attempts to provide a stable fit between the frame and the terra cotta blocks. Through the standards' illustrations, it is implied that hangers should be straight and the terra cotta blocks should be manufactured to fit such a configuration properly.¹⁷⁶ Most likely, these examples from

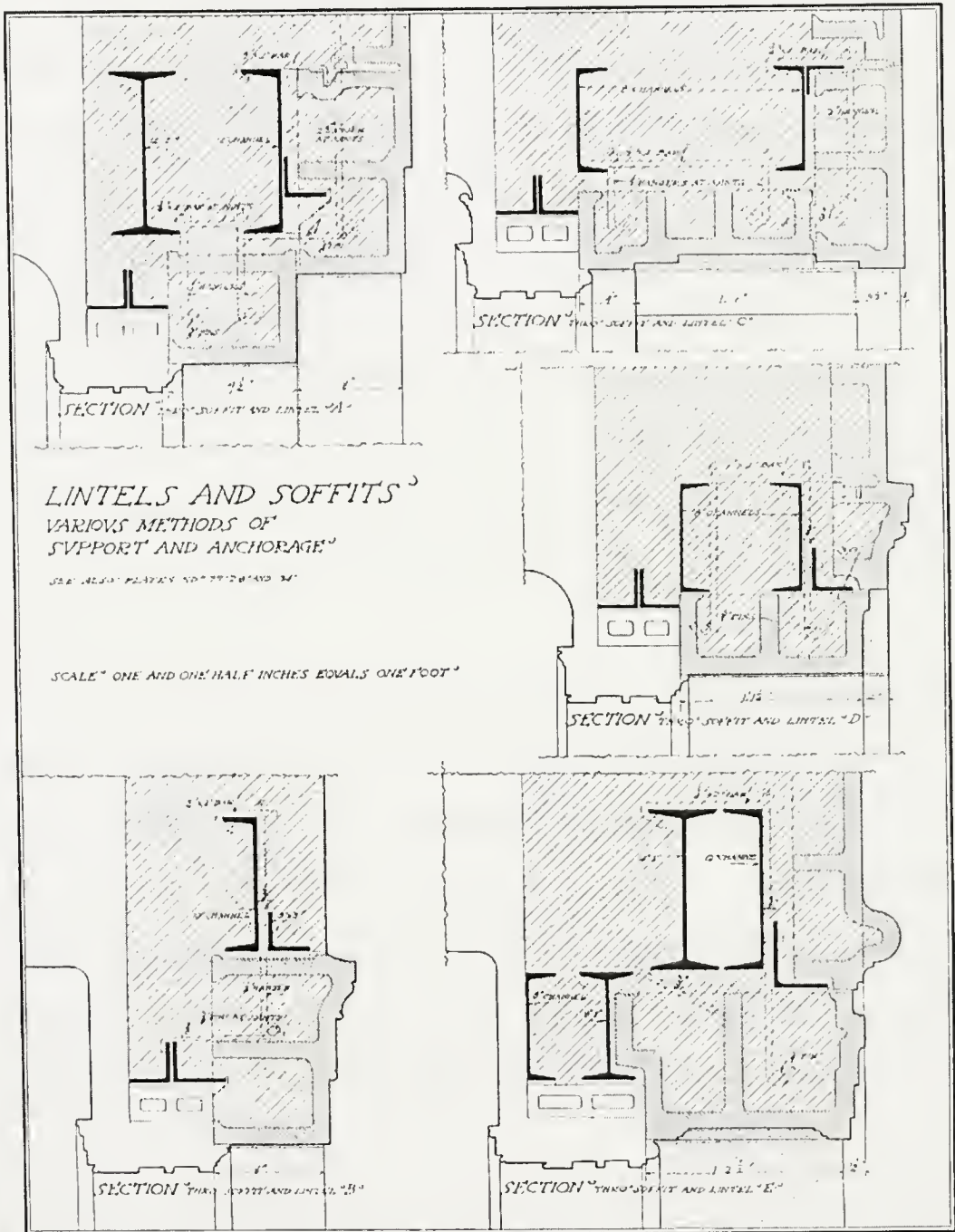
¹⁷⁶ Anchors are commonly bent throughout the standards but hangers are always straight.

the Northwestern Terra Cotta Company reflect the manufacturer's attempt to compensate for incompatible steel framing and terra cotta setting plans as was common at the turn of the twentieth century.



Example 6: Hotel Grunewald (1907). The Northwestern Terra Cotta Company, Order 6367, Drawing 43176, Draftsman: J. A. Ohman

ARCHITECTURAL TERRA COTTA · · · STANDARD CONSTRUCTION

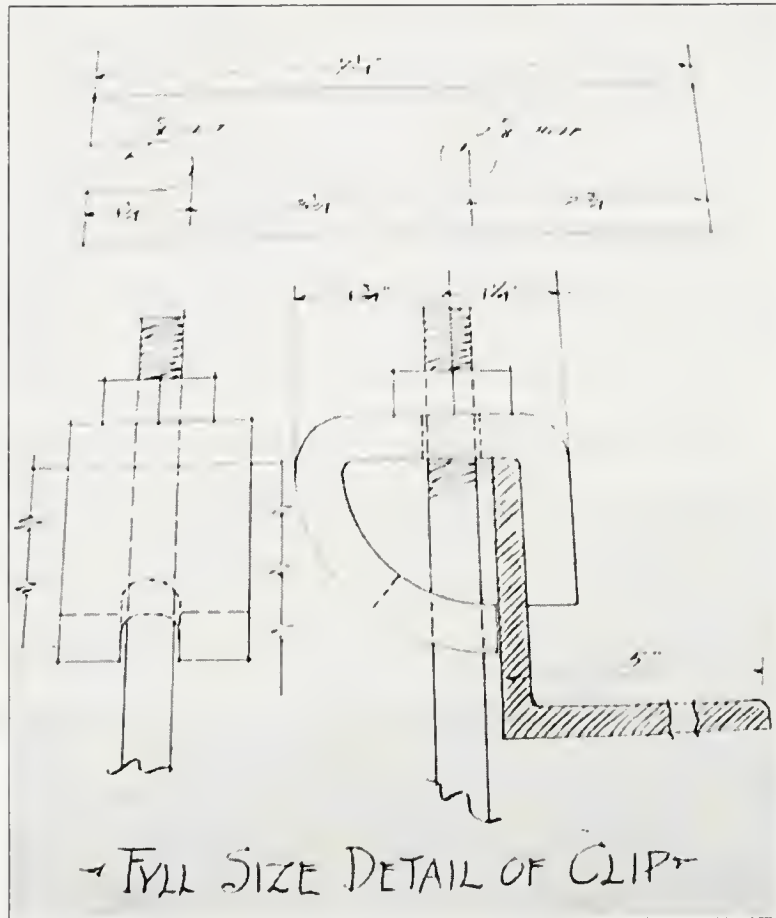


NATIONAL TERRA COTTA SOCIETY · V · S · A · · · PLATE NO · 35

Standard Drawing 3: Taken from 'Lintels and Soffits' plate no. 35 in *Architectural Terra Cotta: Standard Construction* (1914).

The shop drawings from the Northwestern Terra Cotta Company reveal how plates and clips could be used to extend the support of the steel framing members. Example 6, taken from the iron schedule of the 1907 Hotel Grunewald, illustrates a plate resting on top of a C-channel and an I-beam while supporting two J-hook hangers. The plate measures 1/2" thick and 2" wide while the J-hooks, secured by 3/4" diameter pins, range from 3/8" to 1/2" in diameter. The Northwest Terra Cotta Company often used this type of configuration to support a soffit or lintel. While this alternative hanging system is not included in the 1914 standards anchor illustrations, it is used in several section drawings throughout the rest of the book. Plate 35, in particular, details that the bar, or plate, should be 1/2" thick and 2" wide while the J-hooks should be 1/2" in diameter and connect to 5/8" diameter pins in the joints.

It seems risky to secure lintels with bars that are not riveted or clipped to the steel frame. If the lip of the bar or flange of the steel beam were exposed to water, rust expansion and flaking could seriously undermine the strength of the configuration. If the metal supports failed, the terra cotta would rely on the strength of the mortar joint and pin. This type of situation could cause serious injuries to pedestrians walking below as pieces of the soffit or lintel fall to the sidewalk. Yet even with such risks, it seems to have been accepted common practice as it also appears in the 1927 revisions to the Standards.



Example 7: City Hall, Chicago (1909). Northwestern Terra Cotta Company. Order 9001, Drawing 58308, Drafter: Poulson

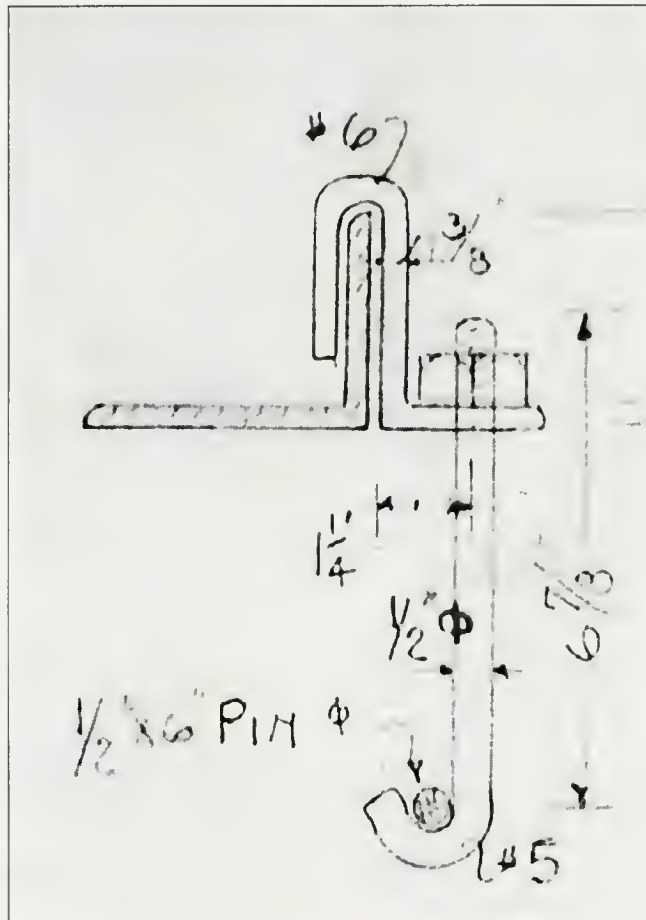
Shop drawings from Holabird and Roche's City Hall in Chicago from 1909 indicate the Northwestern Terra Cotta Company developed a new clip to support a J-hook. This clip retains the same dimension as those previously used at 1/2" thick and 2" wide. A 5/8" diameter hole is made on the top of the clip to receive the J-hook. While one edge of the clip is hooked around the flange of an angle, the other edge returns with an open-ended 5/8" slot to brace the J-hook to the angle. This design does not appear in the 1914 Standards, but figure 16 illustrates a similar piece that supports a J-hook adjacent to the

angle. Perhaps this clip construction used by the Northwestern Terra Cotta Company prompted the National Terra Cotta Society to include this clip type in the Standards.

The O.W. Ketcham shop drawings reveal anchor details that indicate an understanding of the standards but are widely adapted to fit individual projects. The sizes for the metal pieces still vary from project to project but fall within the range of both the 1923 specifications and the 1927 standards. As with the Northwestern Terra Cotta Company, some of the configurations are used directly while others are used in combination to attain the desired strength. Yet, Ketcham deviates from the standards by using bronze, chain, and other anchorage innovations to secure the terra cotta.

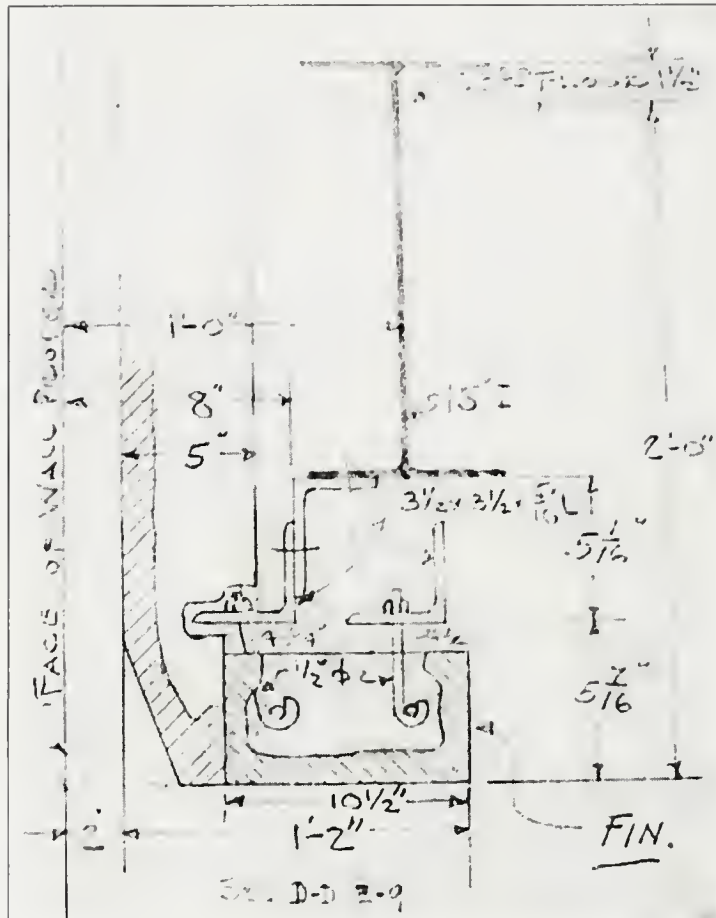
While the Northwestern Terra Cotta Company used Figures 2, 4, 6, 7, and 8 most frequently, Ketcham used Figures 15, 16, as well as 2, 4, and 6. In both companies, the clip is used consistently. Just as in the past, after 1927 the clip, used in Figures 1-4, 6-8 and 16, provided easy installation that allowed for movement over time and was adjustable in the field to adapt to change orders during construction. Figures 6, 7, and 8 as well as 15, are hanging techniques which, despite the increased use of shelf angles and wall anchors, were still seen in 1927 as an effective support mechanism. One of the differences between the two companies is that Ketcham uses more arrangements adjusted for concrete construction. This indicates the shift in technology from 1914 to 1927. The concrete industry begins to take shape during this time as is indicated in the *Standards* in Plate 27, "This plate covers only the construction anchorage and jointing of terra cotta. The engineering problems of reinforced concrete are not especially considered. The terra cotta can be made to suit any

such particular requirement.”¹⁷⁷ With concrete, the anchorage becomes simpler as more pieces can simply be embedded into the material.



Example 8: Market Street National Bank (1930). O. W. Ketcham
Terra Cotta Works, Order 2220, Drawing 16, Draftsman: n/a..

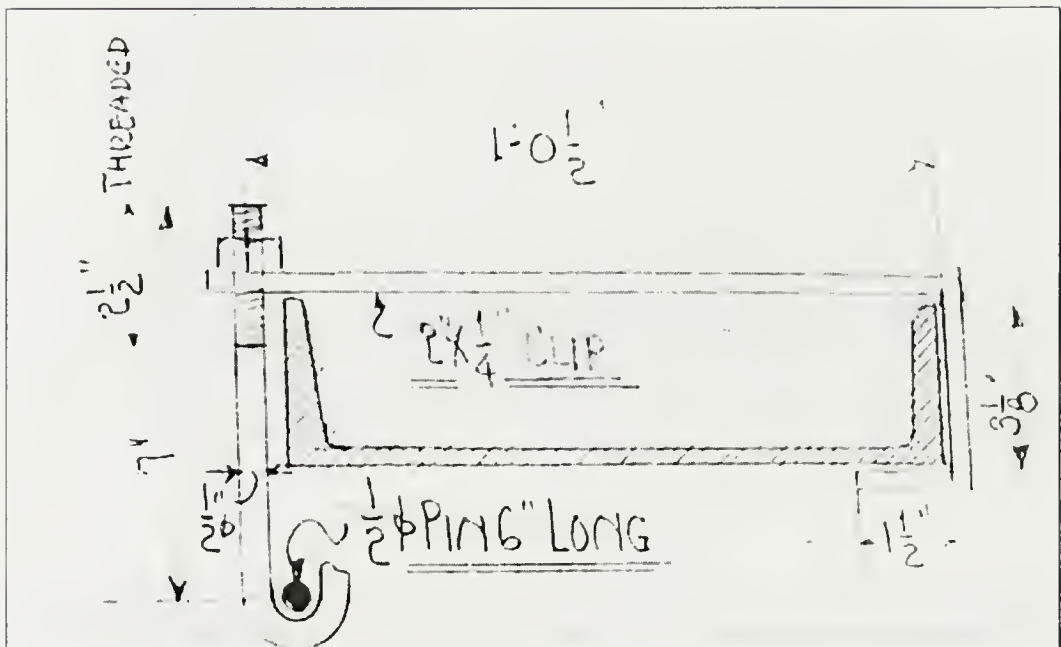
¹⁷⁷ Society, *Terra Cotta: Standard Construction*.



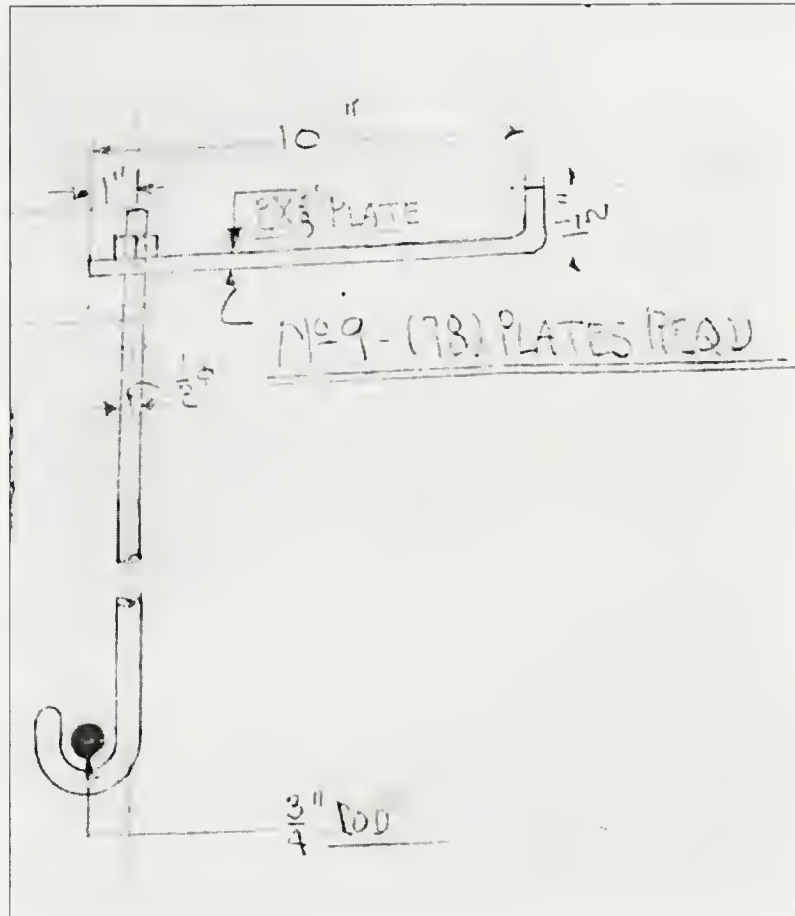
Example 9: Navy Annex Y. M. C. A. (1928). O. W. Ketcham Terra Cotta Works, Order 2091, Drawing 5, Draftsman: Naugle.

This example from the Market Street National Bank in Philadelphia (1930) shows a clip arrangement similar to Figure 4 from the standards. The clip size is much wider and thinner than the standard at 4"x 3/8." Also, the clip extends the 3" length of the angle. This practice is similar to idea behind the plate separator in that the full extension of the clip is fully supported against the length of the angle to prevent twisting. This is certainly an improvement over the 1914 standards. Despite the pervasiveness of the clip, slotted angles were still being used even 1927. Example 9 from the Navy Central YMCA Annex

in 1928 shows the hanging of a soffit with a J-hook supported by an angle. The practice of slotting iron beams, while discouraged, proves to have been widely used by the terra cotta manufacturers.



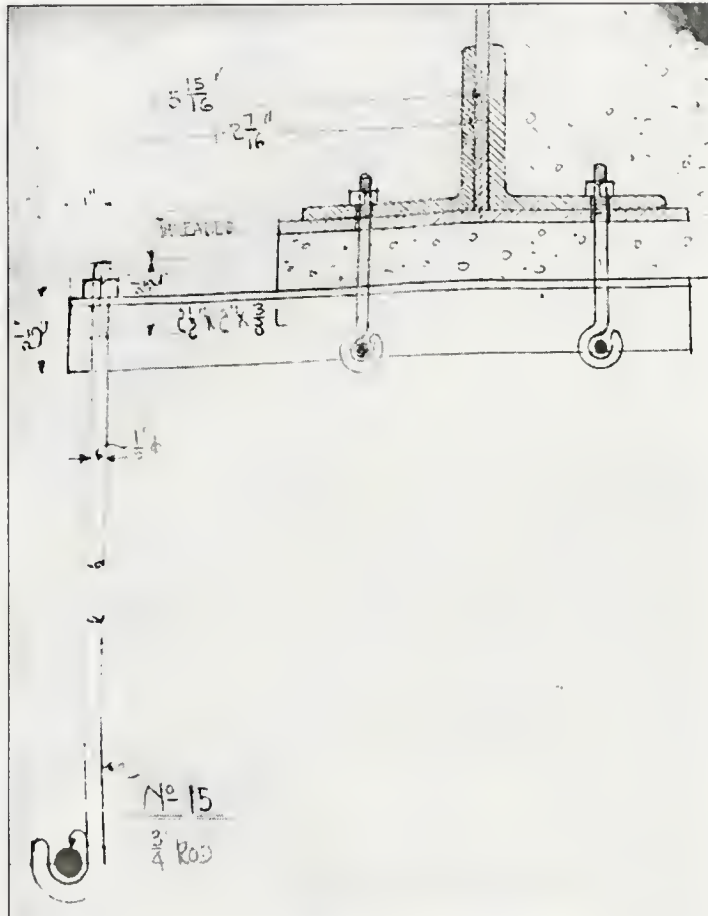
Example 10: Market Street National Bank (1930). O. W. Ketcham Terra Cotta Works, Order 2220, Drawing 12x, Draftsman: n/a.



Example 11: Market Street National Bank (1930). O. W. Ketcham Terra Cotta Works, Order 2220, Drawing 12x, Draftsman: n/a.

While the standards were produced to illustrate the proper methods of construction, many manufacturers took the standards and adapted the configurations to fit their buildings. For example, Ketcham inverted the Figure 8 to a horizontal position in the entrance of the Market Street National Bank (1930) as seen in Example 10. In this case the 2"x 1/4" clip is wrapped around both flanges of the C-channel and supports a 1/2" J-hook. In another adaptation seen in Example 11, Ketcham uses a Figure 6 type configuration but without the

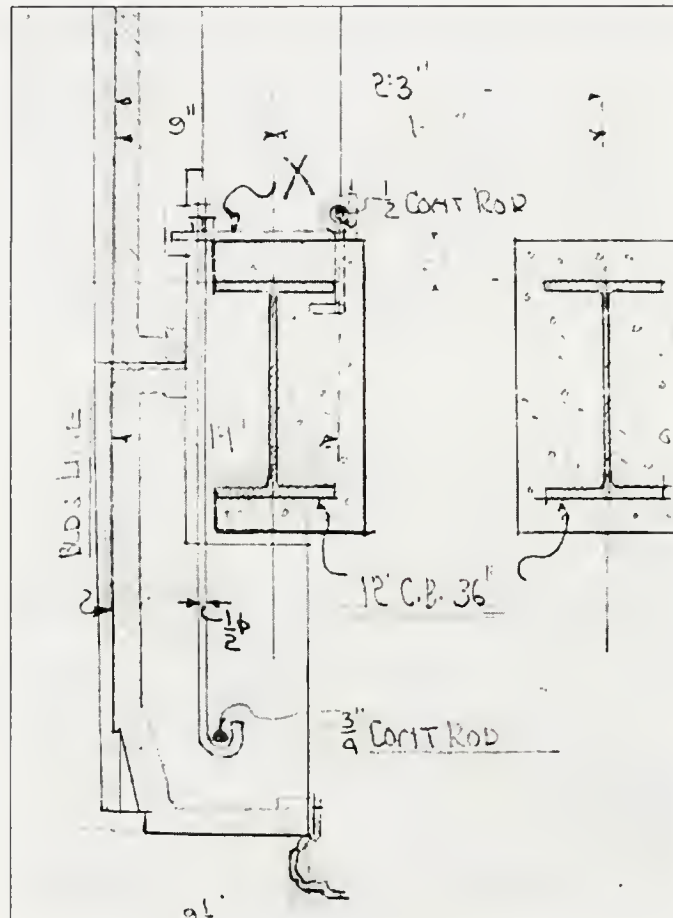
steel beam. In this case, also from the Market Street National Bank, the 1/2" hanger is supported by a 2" x 3/8" clip that is embedded into the wall.



Example 12: Market Street National Bank (1930). O. W. Ketcham Terra Cotta Works, Order 2220, Drawing 12x, Draftsman: n/a.

With a little creativity, some manufacturers were able to combine more than one standard anchorage practice to achieve a particular effect. In Example 12, Ketcham combines the ubiquitous Figure 2 with the more complicated Figure 7 to achieve soffit support. Here, a double angle is bolted to a T-beam with eye-bolts that also serve as hangers. In all of these scenarios, the Ketcham Terra Cotta Works was able to take the

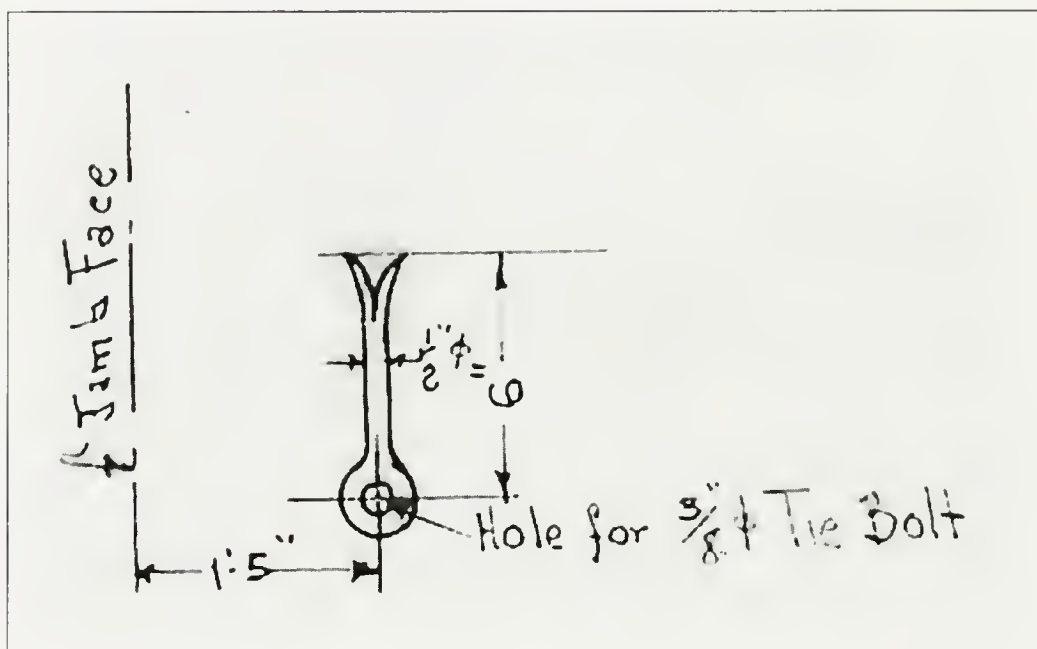
principles outlined in the standards –adjustability, strength –and use the anchorage to fit the individual project.



Example 13: Market Street National Bank (1930). O. W. Ketcham
Terra Cotta Works, Order 2220, Drawing 1x, Draftsman: Moore.

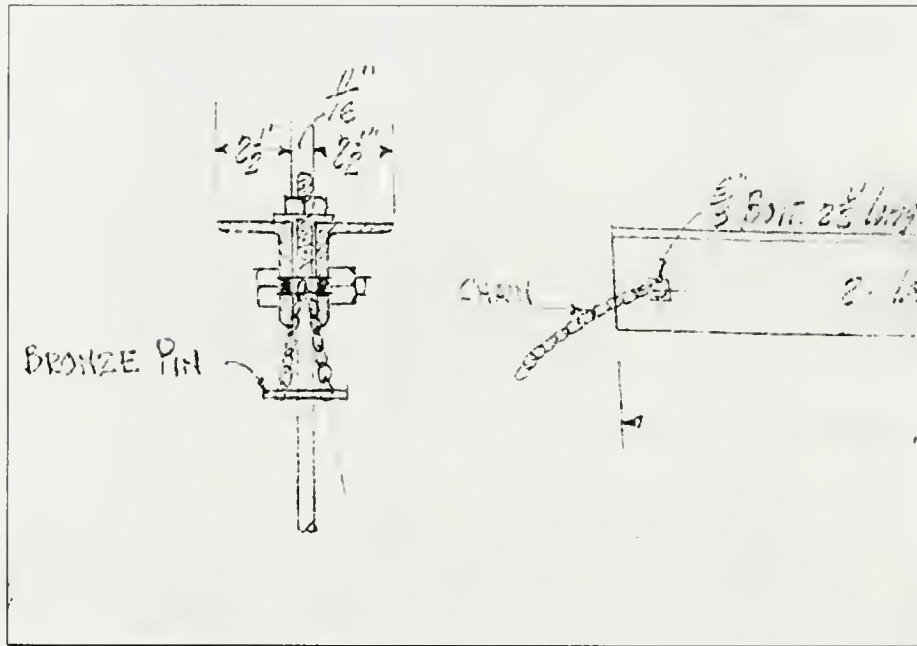
Concrete construction used steel members as reinforcement for the framing system. The anchor system, while dependent on the combined strength of the steel and the concrete, was able to brace flat surfaces against the concrete edge. So in Example 13, the clip is anchored to a threaded eye bolt that is set in the concrete around the flange of the I-beam. The flat edge of the clip is braced against the edge of the concrete and projects slightly to

support a J-hook that holds the terra cotta in place. Such a type of construction was seen as reducing twisting in the anchorage system. It was not used in the ca. 1914 drawings of the Northwestern Terra Cotta Company indicating that its inclusion in the standards was a response to common failures.

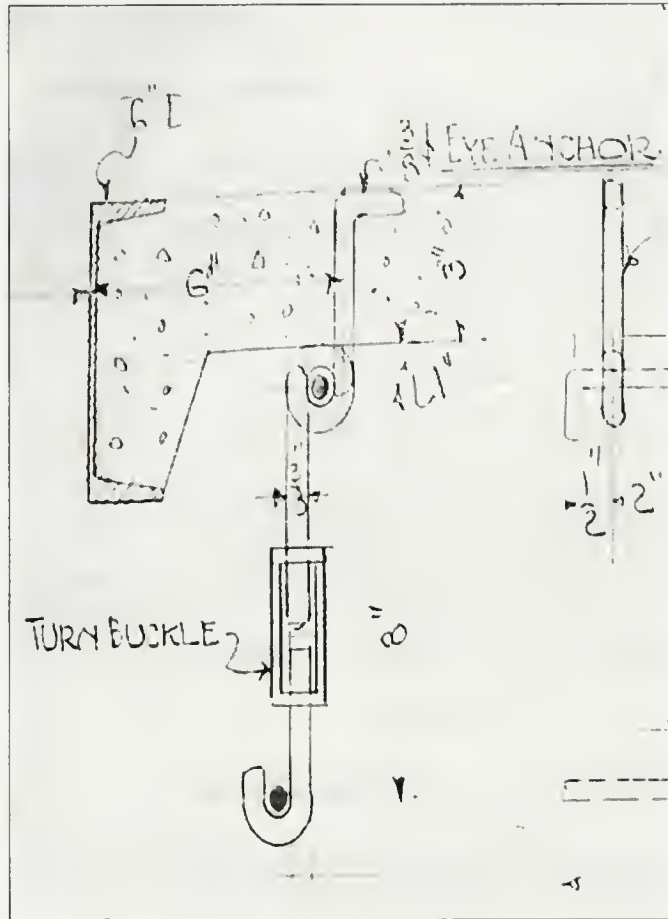


Example 14: Temple Israel (1930). O. W. Ketcham Terra Cotta Works, Order 2250, Drawing 4, Draftsman: Roger.

Just as the Northwestern Company constantly used non-standardized anchors to fit their terra cotta designs, so did the Ketcham Company despite established standards. Concrete construction brought about such innovation in anchorage systems. The standards call for a $\frac{3}{4}$ " anchor with a projecting hook to be set into reinforced concrete. Ketcham used a fish tail $\frac{1}{2}$ " eye bolt instead of the Z-shape eye bolt that was often used. The fish tail, as seen in Example 14 from the Temple Israel, served as teeth that held the anchor in place.



Example 15: West Side Y. M. C. A (1929-1930). O. W. Ketcham Terra Cotta Works, Order 2142, Drawing Sections A-Z and AA-AW, Draftsman: Roger.



Example 16: Sister's of Charity Mother House (1930-1931). O. W. Ketcham Terra Cotta Works, Order 2288, Drawing 16, Draftsman: n/a.

Other non-standard practices used by the Ketcham Company included: a bronze chain and pin, a turn buckle. The chain and pin configuration, in Example 15 from the West Side YMCA, was used to stabilize terra cotta pieces off an outrigger then securing them through pins in the joints. Bronze was hailed as a non-corroding metal while the chain most likely was intended to provide flexibility in the construction. The turn buckle is not defined in the shop drawings but this innovation for the clip appears to also promote flexibility in installation as the J-hook can be manipulated to face either direction. While

anchoring systems must always allow for movement over time, the buckle, as seen in Example 16 from the Sister's of Charity Mother House, seems to act as twist control for the J-hooks that are screwed into it. If screwed in correctly, the turn buckle seems to allow for movement of the J-hook while maintaining the strength of the connection between the terra cotta block and the back-up wall.

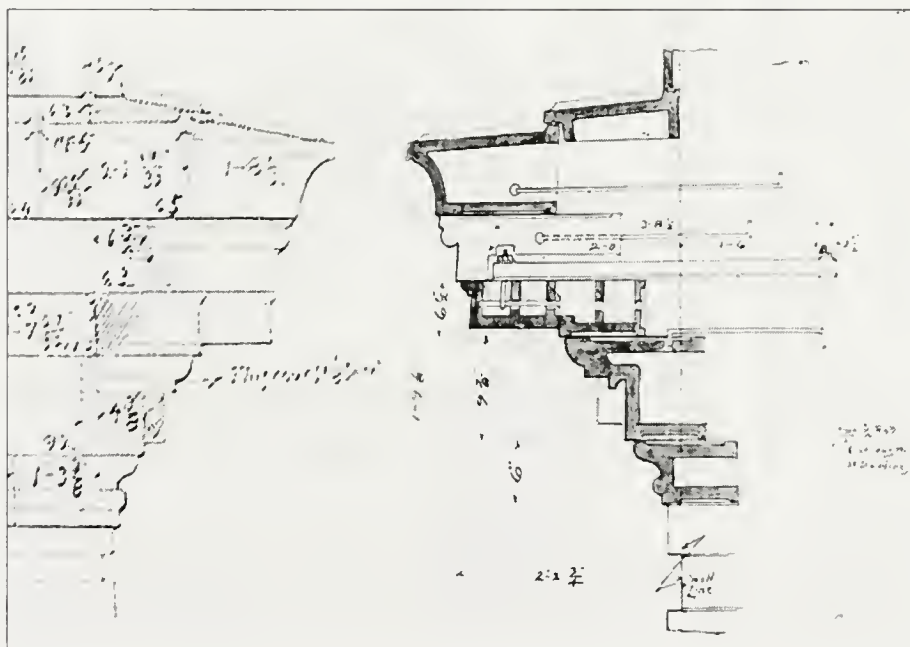
CORNICES

The construction of terra cotta cornices involves some of the most intricate hanging systems to accommodate multiple projections and often highly ornate terra cotta sculpture. Many of the anchoring and hanging techniques outlined in the previous section were used simultaneously to provide the right support for the terra cotta blocks. Anchors, rods, and pins were used to hold the terra cotta courses to the steel frame while double angles, T-beams, and C-channels were used as outriggers for the projecting courses. J-hooks, clips, and plates were used to hang soffits from these outriggers. Warren notes, "...wherever iron is used for tying the cornice to the walls it is necessary to determine the method of anchoring before the pieces are molded, as in manufacturing them holes or slots must be made for inserting the beams, rods and anchors."¹⁷⁸ The cornice was the most important terra cotta element to secure on a building because if the anchorage failed, its pieces had the farthest to fall. The consequences of such a failure jeopardizes the safety of pedestrians walking below let alone the damage to the building itself.

At the turn of the twentieth century, the skyscraper cornice was equivalent to the capital of the ancient Greek column. This crowning element, however, was also the most

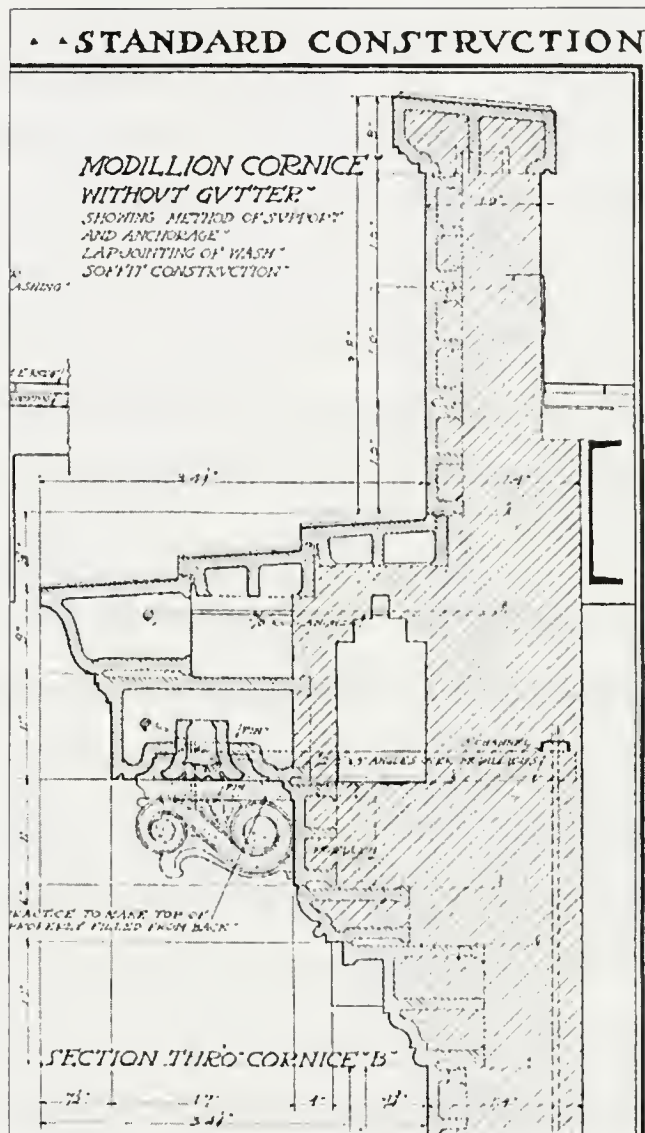
¹⁷⁸ Warren, "Notes on the Standard Form of Specifications for Architectural Terra Cotta," 14.

susceptible to water damage. Improper roof drainage or drainage within the terra cotta blocks themselves exposes the iron hanging systems to water, therefore causing corrosion in the form of rust. This can cause cracking in the terra cotta blocks as the rust expands making the intricate hanging system even more susceptible to water infiltration.¹⁷⁹ The stabilization techniques for deteriorated cornices vary on the type of cornice construction, the system of anchorage used, and the extent of deterioration. An analysis of the shop drawing cornices provides insight into one of these elements, the system of anchorage. The following examples of cornices from the Northwestern Terra Cotta Company and the O. W. Ketcham Terra Cotta Works illustrate the variability in construction both before and after the standards were published.



Example 17: a) Court House, Greenville (1903). Northwestern Terra Cotta Company, Order 317/1903, Drawing 30745, Draftsman: Markle. b) U. S. Post Office, Greenville (1903). Northwestern Terra Cotta Company, Order 317/1903, Drawing 30520, Draftsman: Markle.

¹⁷⁹ See the case study on the Land Title Building, Philadelphia, PA. Jeffery S. Levine, "Stabilization and Repair of a Historic Terra Cotta Cornice," *Preservation Tech Notes: Masonry*, no. 2 (1991).



Standard Drawing 4: Taken from 'Modillion Cornice without Gutter' plate no. 23 in *Architectural Terra Cotta: Standard Construction* (1914).

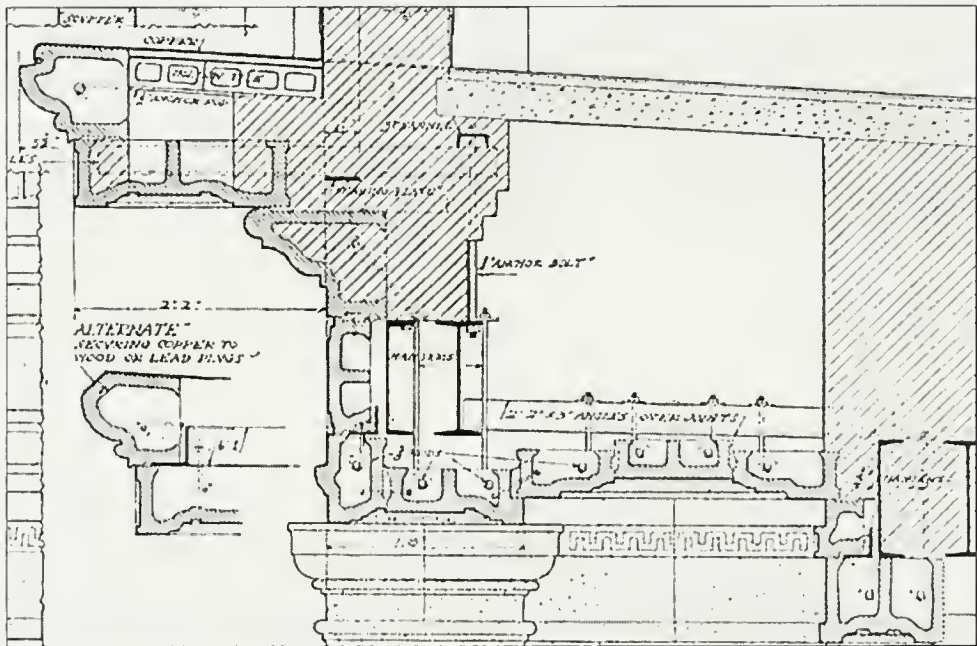
The bracing structure in the modillion cornice illustration from the 1914 standards consists of 3" x 3" double angles that serve as an outrigger for the modillion soffit. This outrigger is secured to the steel frame of the building a few courses below with a bolted

anchor rod. The modillion course as well as the course above it is supported by anchors that connect to the outrigger. The course above the modillions is pinned together at the joints. An anchor wraps around the joint pin and connects around the pipe separator between the double angles of the outrigger. The modillion soffit is hung from the outrigger in a Figure 15 configuration with a J-hook that connects to pins in the joints of the blocks. Every course below the soffit is back-filled with mortar and some courses are anchored to the back up wall. In the Northwestern Terra Cotta Company shop drawing of the Greenville U.S. Post Office (1903) cornice, the soffit is not as large and ornate as the standards' cornice but the construction is identical.

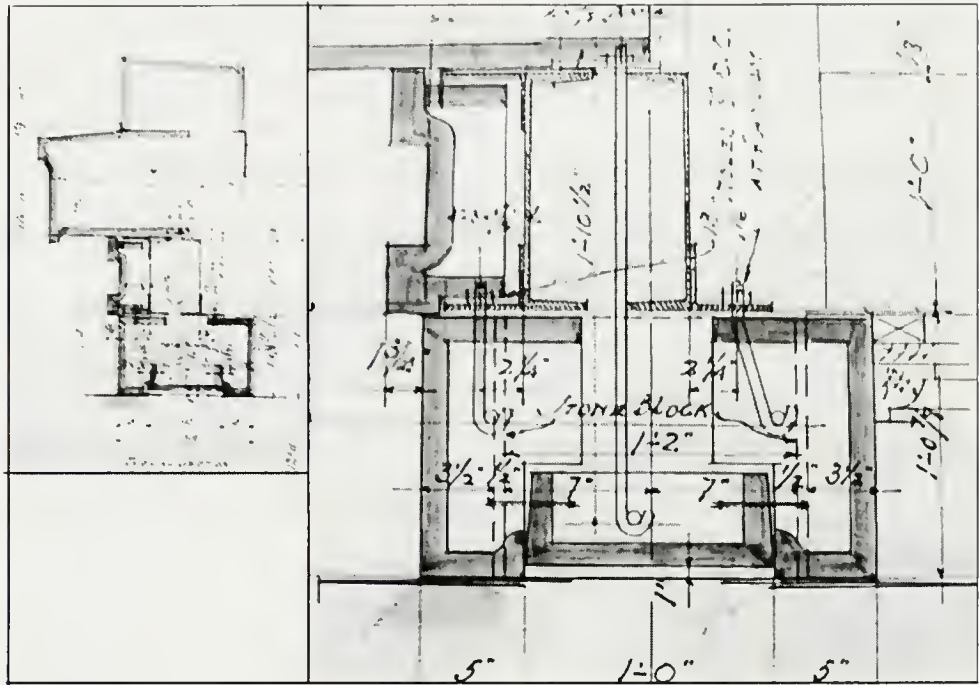
The consequences of back-filling the terra cotta blocks include excess weight, cracking, and low strength. In the early twentieth century, light weight back-filling materials such as mortar breeze, or even mortar with wood shavings, often expanded when wet. This caused pressure build-up inside the voids of the blocks and resulted in stress cracking. As the cracking became worse, more water infiltrated the block, seeped through the porous mortar, and began to corrode the unprotected iron anchors.¹⁸⁰ An additional problem with back-filling the terra cotta with such inferior mortars was the loss of support for the anchor straps. In the Land Title Trust Building in Philadelphia, the pull-out test for the replacement anchors revealed that the mortar had only a 60 psi reading when 500 to 1800 psi was desirable. Not only is this kind of anchorage system vulnerable from cracking and corrosion, but it is also susceptible to complete detachment from the building

¹⁸⁰ John Fidler, "The Conservation of Architectural Terra Cotta and Faience," *Friends of Terra Cotta Newsletter* 3, no. 1 (1983): 12.

frame. For this reason, the standards illustrate all anchors firmly embedded into the brick back-up wall and hooked into a web of the terra cotta block.



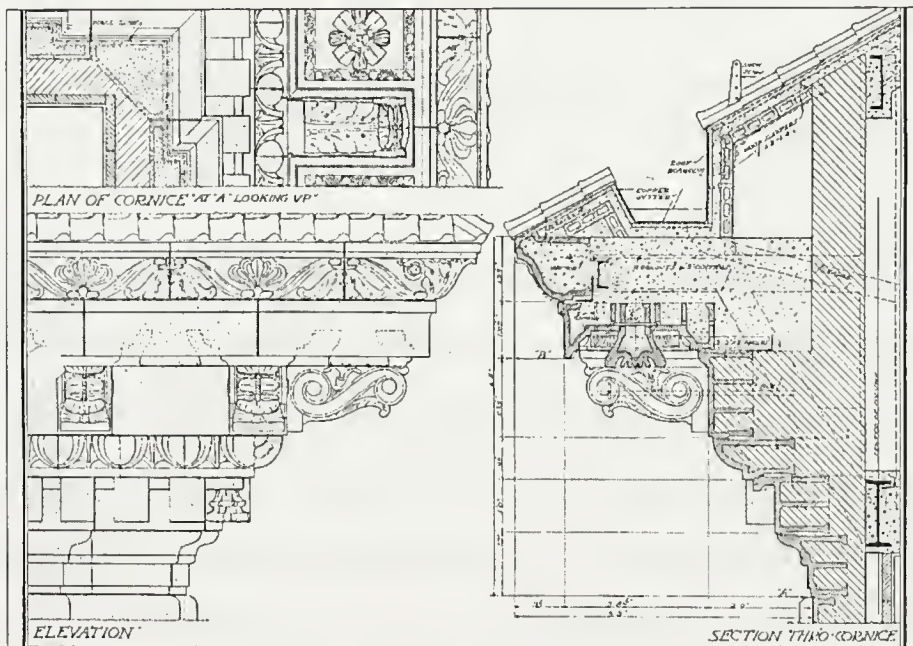
Standard Drawing 5: Taken from 'Cornice with Balustrade' plate no. 26 in *Architectural Terra Cotta: Standard Construction* (1914).



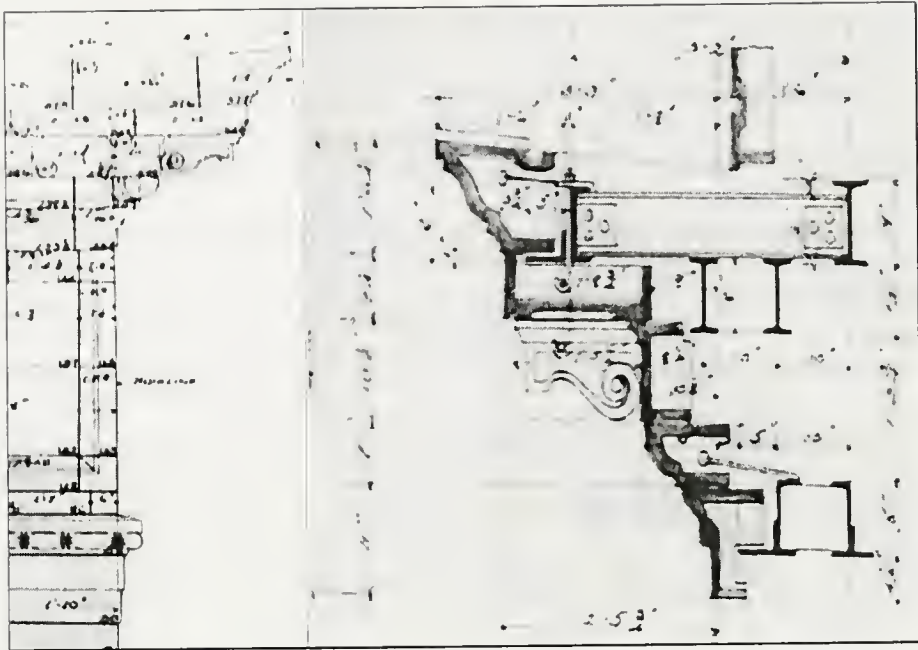
Example 18: Le Moyne Public School (1915). Northwestern Terra Cotta Company, Order 15189, Drawing 9813, Draftsman: ASG

These details illustrate a soffit section of a cornice. The terra cotta blocks depend on the steel beam configuration for support. In the example from the 1914 standards, a steel channel is placed in front of an I-beam. The face blocks are anchored to the C-channel with standard Figure 12 anchors. Additionally, an angle is bolted to the bottom of the C-channel and serves as shelf support for the block above. The corner block where the soffit returns underneath the steel frame is hung from the shelf angle in a Figure 2 configuration with a J-hook. The soffit itself is hung with a J-hook which is bolted to a plate that spans the C-channel and the I-beam. All of the blocks that comprise the soffit are secured together with pins at the joints. The hangers connected to the I-beam support additional soffit pieces.

In the example from the Northwestern Terra Cotta Company shop drawing for the Curry Building (1915), the soffit hanging system exhibits similar construction as the 1914 standards. This example is a smaller soffit than illustrated in the standards, therefore the steel support beams consist of two C-channels facing each other. The corner block is supported in the exact same configuration with the shelf angle. The soffit block is hung with a J-hook that is bolted to a plate that spans the tops of the C-channels. The wall block of the soffit is hung in the same manner as the corner block. All of the blocks of the soffit are secured to each other with pins in the joints.



Standard Drawing 6: Taken from 'Modillion Cornice' plate no. 22 in *Architectural Terra Cotta: Standard Construction* (1914).



Example 19: Fourth National Bank (1905). Northwestern Terra Cotta Company, Order 50/05, Drawing 34297, Draftsman: Reading.

While the first few examples from the Northwestern Terra Cotta Company illustrate the ideas published by the National Terra Cotta Society fairly closely, other examples from the shop drawings reveal similar ideas but different executions. One example in particular is from the Fourth National Bank Building (1905). The shop drawings indicate more iron beams are necessary to support the different courses of the cornice. The 1914 standards suggest using an I-beam outrigger to support the top course that projects the furthest out. To support the outrigger, a diagonal I-beam is riveted to the outrigger and the I-beam embedded in the building column to form a steel bracket. Pipes, anchors, and J-hooks are then used to support the blocks.

In the Fourth National Bank Building, the top course of the cornice is framed in the same way as the standards with a series of J-hooks to secure the brackets. Instead of the outrigger being support by the diagonal I-beam, it is supported by two I-beams running perpendicular to it. The course below the brackets is anchored to two C-channels. An angle attached to the lower part of one C-channel cuts into the webs of the blocks and serves as a shelf angle for an un-anchored course. This is an important distinction from the 1914 standards. The lack of shelf angles has proven to be one of the most problematic elements of terra cotta construction from this era. For this particular project, the Northwestern Terra Cotta Company seems to have been in the forefront of construction technology for terra cotta as shelf angles were omitted from the 1914 model of cornice construction.

A common theme in the deterioration problems of terra cotta construction is excess pressure build-up due to rigid construction. Shelf angles are intended to carry loads at each floor level and relieve undue stress on the terra cotta. Conservators have discovered that even when buildings are constructed with shelf angles, however, the stress problem is not always solved. Expansion joints, rarely included in historic terra cotta construction, below the shelf angle are necessary to allow the building to move with thermal expansion or wind loads. Indications of shelf angle problems include: buckling, cracking, and partial loss at the joints.¹⁸¹ Another problem with shelf angles in construction is their placement in the wall. Modern terra cotta manufacturers, the Boston Valley Terra Cotta Company, specify that all shelf angles should be placed at the joints of the terra cotta blocks to protect the

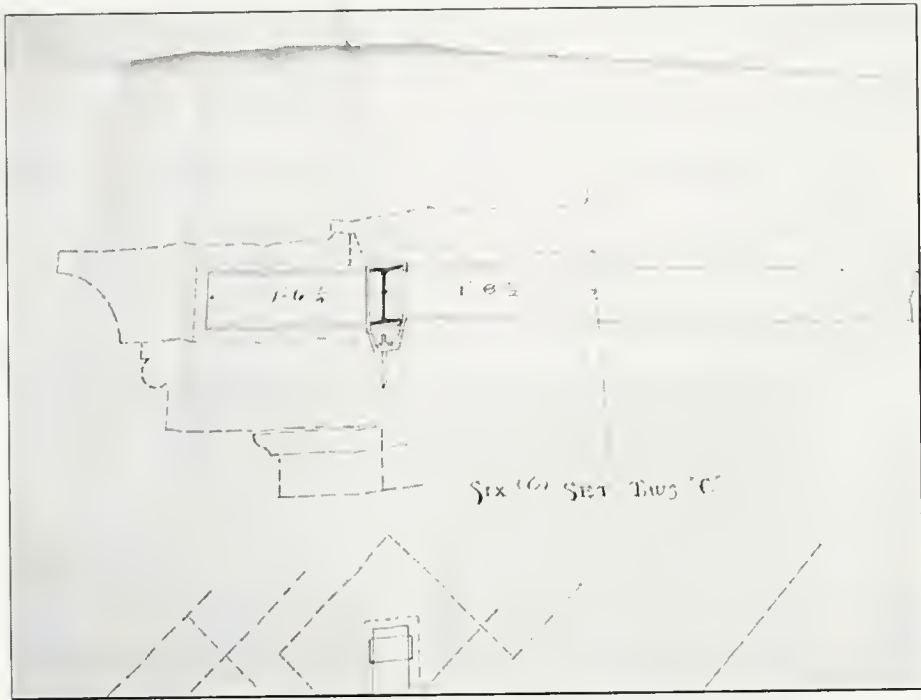
¹⁸¹ C.L. Searls and S.E. Thomasen, "Repair of the Terra Cotta Facade of Atlanta City Hall," in *Structural Repair and Maintenance of Historical Buildings Ii: Proceedings of the Second International Conference Held in Seville, Spain*, ed. Brebbia et al (Seville, Spain: May 14-16, 1991), 250-53.

with extra steel beams. Instead of using an I-beam to support the top course of the cornice, Northwestern specifies a double angle for support. The soffit course is hung from an angle with a figure three anchoring arrangement using a clip and J-hook. The terra cotta blocks are not tied directly to the diagonal angles but to the C-channels in the wall plane. This indicates the diagonal bracket configuration was meant to stiffen the outrigger construction. As with the Fourth National Bank Building, the lower course of the cornice is supported by an angle that is bolted to the C-channel as a shelf support.

John Fidler explains, "It is especially true of extremely tall or large terra cotta buildings that the semi-structural curtain walls tend to move differentially to the steel or concrete frames to which they were fixed originally without the provision of adequate movement joints."¹⁸⁵ The iron bracket was initially installed as protection against the overturning of the cornice construction. However, one component of this arrangement often required the support of a hanger threaded through multiple courses of terra cotta webs in order to obtain the best rigidity.¹⁸⁶ Possibly due to its stiffness or maybe the loss of integrity to the terra cotta, the iron bracket was phased out of the 1927 version of the standards and replaced with more traditional horizontal outriggers.

¹⁸⁵ Fidler, "The Conservation of Architectural Terra Cotta and Faience," 14.

¹⁸⁶ Harry Hundeman and Deborah Slaton, "Final Touch: Cornice Detail," *APT Bulletin* XX, no. 1 (1988).

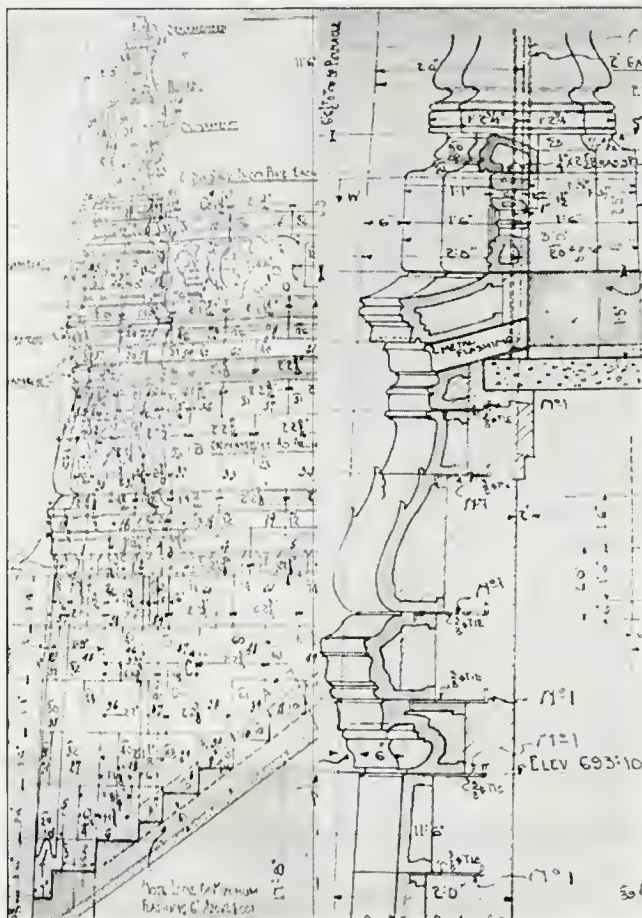


Example 21: Courthouse, Greenville (1903). Northwestern Terra Cotta Company, Order 317/1903, Drawing 30745, Draftsman: Markle.

The application of the Northwestern Terra Cotta Company's anchorage experiments can be identified in the cornice drawings for the Greenville Courthouse (1903). In every cornice example either from the shop drawings or the standards, the soffit of the cornice is suspended from an iron beam with a J-hook configuration. In Example 21, the soffit construction principle is unchanged but the mechanism is different. The J-hook is hung from the I-beam with a metal harness that slips around the I-beam like a garter belt, to borrow from the 'belt and suspenders' anchorage metaphor. This harness is then bolted to an I-beam. Therein lays the difference between the accepted practice after 1914 and before. Bolting the harness to the beam creates rigid structure that is unable to adjust to movement within the building over time.

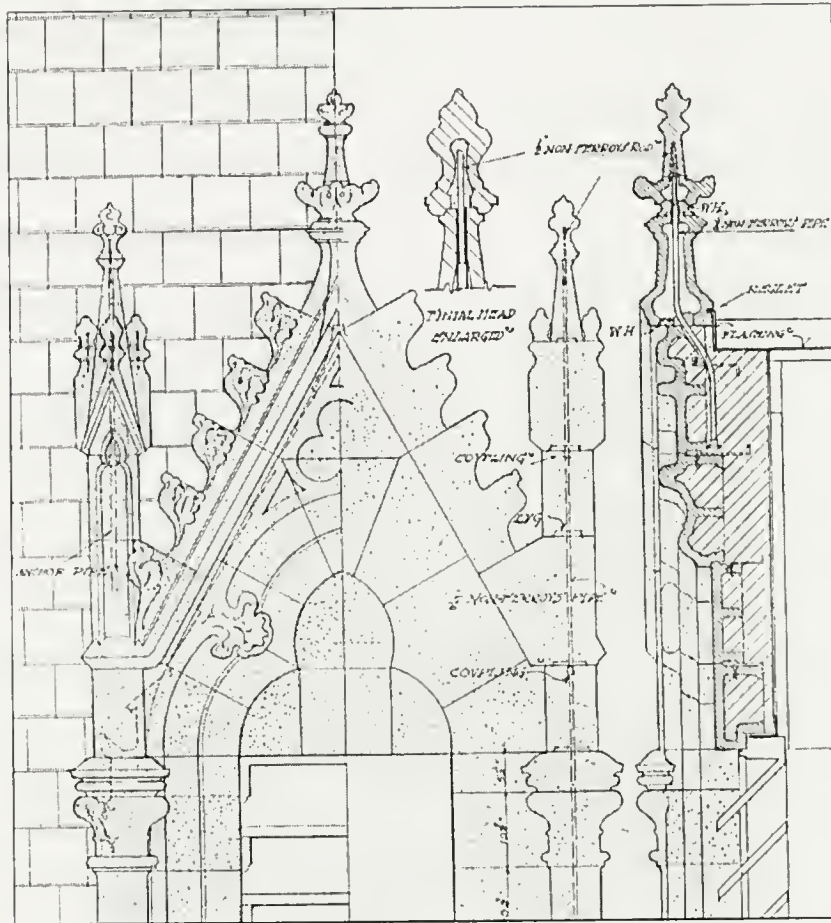
Adjustability is emphasized repeatedly in the anchorage details of the standards.

An indication that the anchorage system is inadequately adjusting to movement in the terra cotta construction is the presence of vertical cracks. Such cracking is the result stresses due to thermal movement or water absorption.¹⁸⁷



Example 22: Sister's of Charity Mother House (1930-1931). O. W. Ketcham Terra Cotta Works, Order 2288, Drawing 11, Draftsman: Moore.

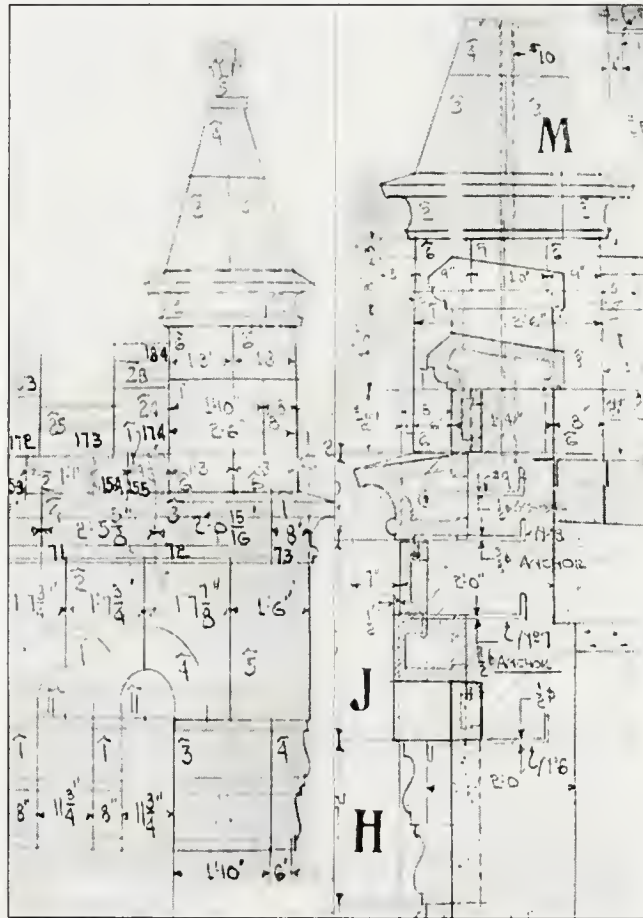
¹⁸⁷ Meadows, *Historic Building Facades: A Manual for Inspection and Rehabilitation*, 65.



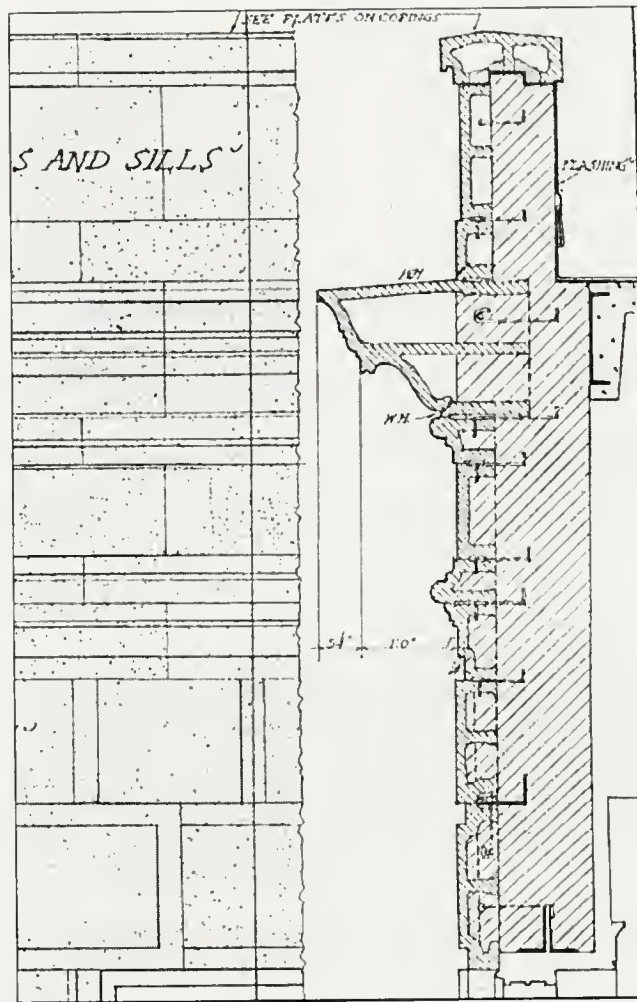
Standard Drawing 7: Taken from 'Louvered Dormer' plate no. 47 in *Terra Cotta: Standard Construction* (1927).

One of the more elaborate projects from the Ketcham examples includes the Mother House for the Sisters of Christian Charity (1930-31). Ironically, this ornate pedimented cornice uses a fairly simple anchoring system similar to the standards' 'Louvered Dormer' example on Plate 47. In both examples, a pipe is threaded through the decorative final to give the vulnerable piece proper anchorage. The pipe is not meant to protect the cornice from water but flashing is specified where the parapet meets the wall line to prevent water infiltration. Each terra cotta block is then tied to the back up brick wall with standard

Figure 13 anchors. The main difference between the two section drawings lays in the indication of weep holes at drainage points. The 1927 standards strongly emphasized the use of weep holes to prevent water from pooling within the blocks and cause failures. It is possible that Ketcham used weep holes but did not include them in shop drawings especially as flashing and drips are included throughout all the sample shop drawings.



Example 23: Redemptorist Father's Community House (1932). O. W. Ketcham Terra Cotta Works, Order 2348, Drawing 5, Draftsman: Moore.



Standard Drawing 8: Taken from 'Cornice with Parapet' plate no. 31
in *Terra Cotta: Standard Construction* (1927).

These examples display cornice section drawings for parapet construction. The system of anchoring is fairly straightforward with every block tied to the back-up wall. It is significant to note that the copings on the parapets from both examples are not anchored but set in place by mortar. While it is not clearly visible in the Ketcham example from the Redemptorist Father's Community House (1932), both drawings incorporate flashing at the roof line with different techniques. The standard example extends the flashing underneath

the coping down to the roof line. To prevent water infiltration where the flashing sheets come together, the sheets are folded over like a paper bag in roll joint. The flashing technique of the Community House does not install flashing underneath the entire coping of the parapet. Instead, a smaller piece of flashing wraps around the edge of the parapet beneath the coping which extends over the piece of copper flashing at the roof line in a lap joint. In this situation, it would have been prudent for the Ketcham Company to follow the standards. Extending the flashing across the width of the coping prevents the saturation of the wall below thus protecting the anchorage system from corrosion.¹⁸⁸

Eskesen explains faulty parapet construction:

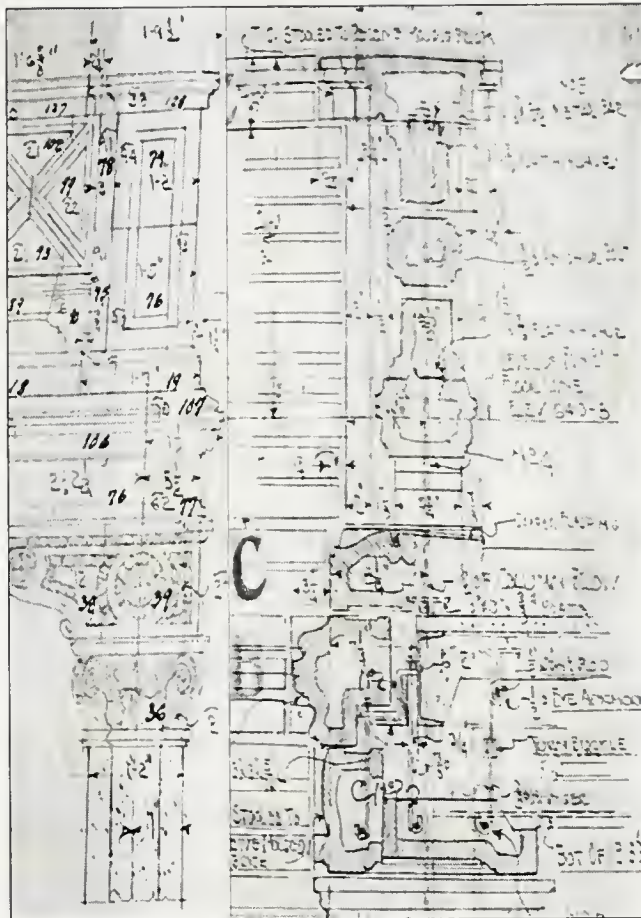
It is obvious that there are instances where infiltration of water is caused by defective architectural engineering, causing faulty structural conditions, for instance, at the back of parapet walls, where the roofing material is joined to the wall structure. If defective material is used, leaks will develop within two or three years. This will also happen if good material is used improperly or if no flashing or insufficient flashing is used. The roof becomes a reservoir from which water is distributed into the exterior wall structure.¹⁸⁹

Indeed, conservators examining the cornice of the Land Title Trust Building in Philadelphia, Pennsylvania, discovered that the primary reason for the terra cotta deterioration and anchor corrosion was inadequate flashing at the roofline. New stainless steel anchors had to be inserted through the face of the terra cotta blocks to stabilize the structure.¹⁹⁰

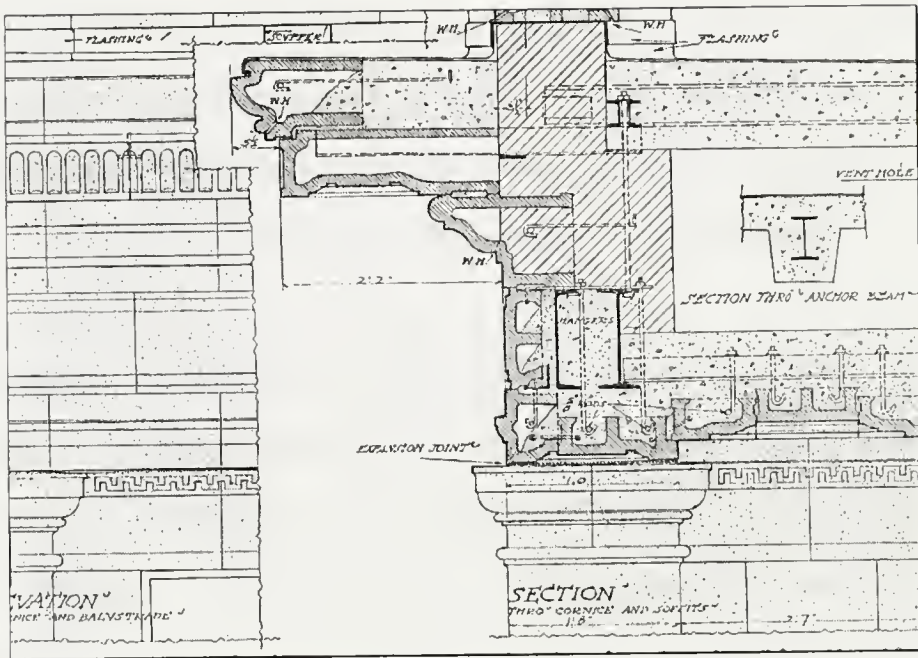
¹⁸⁸ Samuel Y. Harris, *Building Pathology: Deterioration, Diagnostics, and Intervention* (New York: John Wiley & Sons, 2001), 589-90.

¹⁸⁹ Eskesen, "Watertight Terra Cotta Construction," 159.

¹⁹⁰ Levine, "Stabilization and Repair of a Historic Terra Cotta Cornice."



Example 24: Sister's of Charity Mother House (1930-1931). O. W. Ketcham Terra Cotta Works, Order 2288, Drawing 2, Draftsman: Moore.



Standard Drawing 9: Taken from 'Cornice with Balustrade' plate no. 26 in *Terra Cotta: Standard Construction* (1927)

As a further example of the variety of work within one company, this section drawing from the Mother House for the Sisters of Christian Charity (1930-31) illustrates the standard method flashing a parapet wall. Example 24 and Standard Drawing 9 are cornice sections with balustrades and soffits. The scale between the two examples is slightly different but comparisons can be made regarding the soffit configurations. The standard illustration uses a double J-hook configuration similar to the one discussed in Example 6. The J-hooks are suspended from a C-channel and an I-beam to support the soffit blocks. A third J-hook in a Figure 2 assembly off the shelf angle supports the corner block of the soffit. In the Ketcham example, a different kind of double J-hook hanger is used. Here, a Figure 3 clip resting on an angle bolted to the C-channel supports J-hooks that secure two different soffit blocks. Additionally, the angle serves as a shelf support for

the block above it. The wall edge block of the soffit is supported by a turn buckle that connects around a concrete eye-bolt. In the standard section drawing, the deeper soffit is hung in a standard Figure 7 configuration. Once again, the terra cotta company has deviated from the standards to accommodate project specific requirements.

This research into the shop drawing details of anchorage systems has revealed that the NTCS standards did indeed evolve from common practice. The use of clips and slotted angles seems to have been used widely for a considerable period. If one were to study the standards as a guide, however, one would ignore the widely applied practice after 1914 and 1927 of adapting the standards configurations to fit the design of a particular building. The anchorage systems often were combined, inverted, and substituted to fit the steel frame and the terra cotta block design. One of the most surprising discoveries is that even the anchorage thicknesses, something that seems easily regulated, varied from project to project. While most pieces measured within a small percentage of the desired size, there was still a wide variety employed in terra cotta buildings.

Even though the standards were not followed as closely as one might expect, the ideas implied in plates 70 and 67 –non-corrosive metal, adjustable construction, multiple anchors –were followed fairly closely in the practices of the Northwestern Terra Cotta Company and the O. W. Ketcham Terra Cotta Works. The shift of technology to including new water protection techniques and concrete construction can most definitely be seen in the shop drawings. In many ways, these shifts in technology can be traced through the use of innovative new techniques that go beyond the understanding of the National Terra Cotta Society at the time they produced the revisions to the *Standards* in 1927.

CONCLUSION

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Like the dots and dashes of the Morse Code, the configurations of anchors appear at first glance like an encrypted code on the terra cotta manufacturer's shop drawings. When using the standards as a code breaker most of the construction message becomes clear but additional information is required to fill in the gaps. As the analysis of the shop drawings indicates, the terra cotta industry was constantly evolving to adapt to new building technologies. Unfortunately, what was specified on the shop drawings was not always implemented during construction.¹⁹¹ On-site investigations provide the most conclusive confirmation of the anchorage systems used within the building but can also be destructive to original fabric. Using all three of these tools together –the standards, the shop drawings, and site analysis –the conservator can decode the anchorage system of a particular project and begin to translate the technology for modern use.

While the 'belt and suspenders' technique of securing terra cotta blocks to the steel frame with anchors and hangers is no longer a modern construct, Architects, Engineers, and Preservationists have to understand how the system worked, or didn't work, in order to restore terra cotta buildings. In most cases, it is impractical and too costly to dismantle an entire terra cotta façade, design a new engineering plan to anchor the existing blocks, and the reconstruct the building.¹⁹² Instead, the conservation professionals have to implement a

¹⁹¹ Deborah Slaton and Mark Robert Morden, "Issues in the Salvage and Reuse of Terra Cotta: Two Case Studies," in *Standards for Preservation and Rehabilitation, Astm Stp 1258*, ed. S. J. Kelley (American Society for Testing and Materials, 1996).

¹⁹² Interview with Neal Quenzel, John Milner and Associates, March 25, 2003.

restoration plan that reinforces, by-passes, or replaces existing systems. Deborah Slaton explains:

Where terra cotta units are removed and reinstalled in a new building façade, the opportunity exists for redesign of details for better anchorage and flashing. The reinstallation design and new anchorage should be adapted to accommodate the existing terra cotta units wherever possible by conforming to the shapes, sizes, and configuration of the existing units. If modifications to the existing units are required to permit reinstallation, these should be made without intrusion to the original appearance of the units.¹⁹³

Professionals with experience in terra cotta restoration claim the most common techniques include reinforcing the structural system with new stainless steel anchors, by-passing the steel frame system by installing new anchors into the back-up wall, or replacing the insufficient shelf angles with stainless steel angles complete with expansion joints.¹⁹⁴

With the transition in building technology from load bearing structures to skeletal steel frame structures, the terra cotta industry was forced to reassess anchor hardware, water-tight construction, and material strength. The National Terra Cotta Society published standards to aid architects and engineers with their designs for terra cotta buildings during the transition in the early twentieth century. Standards and specifications were written to facilitate communication between manufacturers, architects, and engineers so that the material would be installed at its optimal performance. Today, the same structural elements are being challenged in historic terra cotta buildings as the buildings deteriorate from neglect or from the retrofitting of unsympathetic modern mechanical systems. The NTCS standards and the specifications written during the age of terra cotta construction

¹⁹³ Slaton and Morden, "Issues in the Salvage and Reuse of Terra Cotta: Two Case Studies," 310.

¹⁹⁴ Interview with F. Neale Quenzel, A.I.A., Vice President at John Milner and Associates, 3/25/03; Interview with Carl Baumert, E.N., Senior Consultant at Keast and Hood Engineering Company, 3/25/03; Interview with Mary Oehrlein, A.I.A., Principal at Oehrlein and Associates, 3/26/03.

continue to aid an inter-disciplinary approach to addressing building problems. Architects, Engineers and Preservationists must work together to decode the historic terra cotta anchorage systems and ensure the building functions at optimum performance until the next shift in building technology.

APPENDIX A: NATIONAL TERRA COTTA SOCIETY MEMBERS (1927)

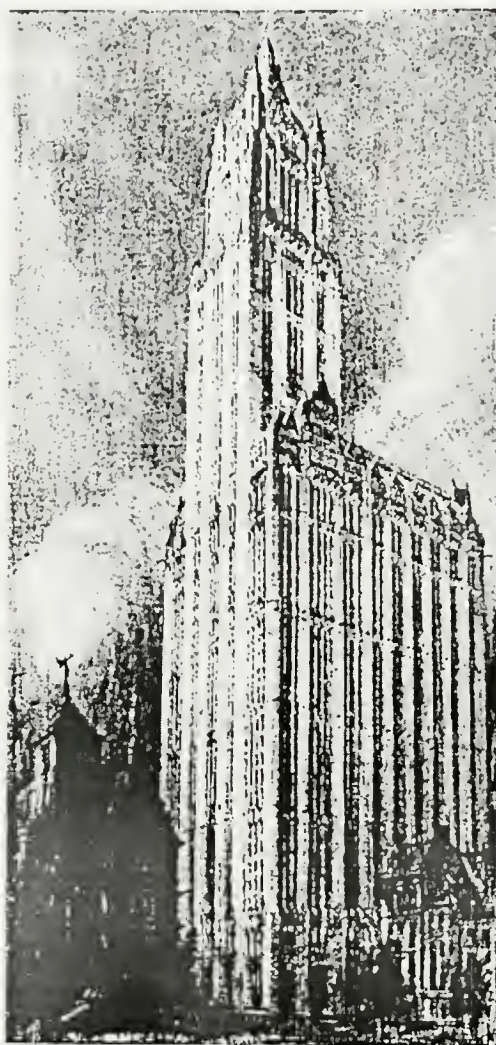
LIST OF MEMBERS 24-53:26
National Terra Cotta Society
29th General Meeting
Schenectady, June 2-4, 1927

1. W. J. Stephani, Ceramist, C. W. Ketcham.
2. W. D'Arcy Ryan, Director, Illuminating Engineering Laboratory, G. E. Co.; Schenectady.
4. Thos. F. Armstrong, President, Conkling Armstrong Terra Cotta Co.
5. L. A. Hawkins, Engineer, Gen'l. Research Laboratory, G. E. Co., Sch'dy.
6. DeForest Grant, President, Federal Terra Cotta Co.
7. Geo. F. Packt, Vice-Pres. Northwestern Terra Cotta Co.
8. F. S. Laurence, Executive Secretary, National Terra Cotta Society.
9. Howard Sharpe, Lamp Dept., G. E. Co., Main Park, Cleveland, Ohio.
10. R. E. Johnson, Industrial Comm. Dept., G. E. Co., Schenectady.
11. Fritz Wagner, American I. C. & Ceramic Co. (also representing Indianapolis I.C.Co.)
12. F. Cernak, Supt. Porcelain Works, G. E. Co., Schenectady.
13. L. C. Hill, Ceramist, Conkling Armstrong T. C. Co.
14. A. E. Croff, Newspaper Publicity Service, N. T. C. Society.
15. Frank Moran, Philadelphia Office, G. E. Co.
16. A. F. Heath, Gladding McBean & Co.
17. W. J. Lucas, Pres. Nat'l. I. C. Soc'y., V.P., Northwestern T. C. Co.
18. W. X. Howell, President, Atlantic Terra Cotta Co.
19. F. A. Buttrick, General Electric Co., New York Office.
20. Percy Worth, Mgr. Central Station Dept., G. E. Co., Cleveland.
21. Scott Sutton, A. & C. E. Service Bureau, General Electric Co., Sch'dy.
22. Robert Ketcham, C. W. Ketcham.
23. G. W. Tucker, Ceramist, N. Y. Architectural I. C. Co.
24. W. L. Mums, Industrial Dept., G. E. Co., Schenectady.
25. Dr. L. Havins, Ceramist, G. E. Co., Schenectady.
26. W. A. Hull, Ceramist, Midland I. C. Co.
27. Walter Geor, Jr., N. Y. Architectural I. C. Co.
28. Karl Mathiasen, New Jersey Terra Cotta Co.
29. C. E. Conkling, V. P. Conkling Armstrong T. C. Co.
30. W. A. Schoepfer, American I. C. & Ceramic Co.
31. Ray Wiley, American I. C. & Ceramic Co.
32. W. L. Irwin, Industrial Mgr. Dept., G. E. Co., Schenectady.
33. A. F. Grady, Vice-Pres. Northwestern T. C. Co. (Missouri)
34. Leo Thurlimann, Ceramist, Midland I. C. Co.
35. Homer C. Thompson, Ceramist, Midland I. C. Co.
36. A. G. Schurecht, Nat'l. Soc'y. Fellow, Nat'l. Bureau of Standards.
37. C. W. Ketcham.
38. W. L. Howatt, Ceramist, Atlantic I. C. Co.
39. J. C. Sloan, Floodlighting Sales Section, G. E. Co., Schenectady.
40. C. F. Scott, Industrial Dept., General Electric Co., Schenectady.
41. H. A. Mahan, Illuminating Engineering Laboratory, G. E. Co., Schenectady.
42. H. B. Key, Vice-Pres. & Gen'l. Mgr., Atlanta Terra Cotta Co.
43. J. T. Appleton, Industrial Dept., G. E. Co., Schenectady.
44. F. A. Benford, Illuminating Engineering Laboratory, G. E. Co., Sch'dy.
45. Geo. Gregory, Corning I. C. Co.
46. B. J. Maccliff, Ceramist, Northwestern I. C. Co.
47. A. F. Dickerson, Mgr. Illuminating Laboratory, G. E. Co., Schenectady.

- 48: I. Scrutinin, Genl. Outdoor Adv. Co., Chicago.
- 49: M. C. Gregory, President, Corning T. C. Co.
- 50: F. H. Bates, Chief, Ceramic Div., Natl. Bureau of Standards.
- 51: C. Fidler, Engineer of Standards, Atlantic T. C. Co.
- 52: Oscar Mathiasen, Ceramist, New Jersey Terra Cotta Co.
- 53: A. J. Johnston, Director of Engr., National T. C. Society.
- 54: H. F. Dalton, President, N. Y. Architectural T. C. Co.
- 55: Peter C. Olsen, Treasurer & General Manager, South Amboy T. C. Co.
- 56: R. L. Clare, Supt. Ceramist, Federal T. C. Co.
- 57: A. L. Wright, Industrial Engr. Dept., C. I. Co.
- 58: Adolph Hottinger, Vice-Pres. Northwestern T. C. Co.
- 59: Jack Curry, Mgr. Terra Cotta Service Bureau, Chicago.
- 60: S. H. Putnam, Publicity Mgr., Atlantic T. C. Co.
- 61: H. H. Gates, American T. C. & Ceramic Co.

APPENDIX B: CORRESPONDENCE AND ADVERTISEMENTS

A CAMPAIGN *for* BETTER UNDERSTANDING



Copyright 1930 by National Terra Cotta Society Drawing by Hugh Ferriss

THE WOOLWORTH BUILDING
CASS GILBERT, ARCHITECT

EVERY Architect knows that the profession of architecture calls for more than design, supervision, engineering and all else that goes to create a building.

The profession of Architecture calls for BETTER UNDERSTANDING of its aims on the part of the general public.

The Public should share the Architect's vision—should appreciate the ideals as well as the problems which enter into architecture.

To bring about this better understanding National Terra Cotta Society has planned a series of full page advertisements in "The Literary Digest."

It is the purpose of the advertisements not only to increase public admiration for the Architect and his judgment, but to set forth, as well, the practical and aesthetic qualities of Terra Cotta as an architectural material of permanence, beauty and profit.

Every Architect is earnestly invited to read this unusual series of advertisements.

National Terra Cotta Society is a bureau of service and information operating for the Terra Cotta manufacturers of the United States. Its publications cover not only the technical and structural use of the material but show, as well, examples of its application to buildings of various types.

Brochures of specific value, as indicated by their titles, will be sent to Architects on request:

The School The Theatre The Garage The Store The Bank

These brochures consist of a selection of illustrations, with text and comment, showing representative Terra Cotta buildings of the respective types.

Terra Cotta—Standard Construction

A Valuable Technical Reference Work for Architects and Engineers

TERRA COTTA

Permanent

Beautiful

Profitable

September 10, 1914.

Mr. C. L. H. Wagner,
Northwestern Terra Cotta Company,
2525 Clybourn Avenue,
Chicago, Illinois.

Dear Mr. Wagner:-

I had a very delightful conference with Mr. O. Wenderoth, Supervising Architect of the Treasury. He is a most estimable gentleman, - fair, square and businesslike, - and there is every reason for believing that, under his administration, very much of Government red tape, characteristic of this office in the past, will be eliminated if Mr. Wenderoth is given a good, fair chance.

He frankly stated that, unless he can get good architectural terra cotta, he will use no architectural terra cotta. He appreciates that this material has many qualities when "well made, properly set and carefully pointed", but he also knows that there are several qualities of ware on the market, - "good, bad and indifferent," and that, in the past, no way of controlling a contractor in the selection of sub-contractors has been possible so far as his office is concerned.

He finds that he cannot follow the rule of private practitioners and specify the best companies by name; neither does he feel at liberty, just yet, to reserve the right to approve the selected sub-contractor for architectural terra cotta. To do so, he says, would inevitably result in a lot of wire-pulling as the part of rejected sub-contractors, and this would keep himself and his office in hot water continually.

For the present he desires a terra cotta specification very exacting in the matter of quality, yet fair and reasonable for the first class manufacturer. If this fails he will limit the use of architectural terra cotta unless some other means can be found by which only the best quality of material can become part of his construction. The difficulties of exactly working this out are rather numerous, but here is an instance in which an important Government Department is greatly desirous of "restraining trade" by limiting free and open competition. We are writing you the substance of the interview as regards this point and hope you may have some practical suggestions to make.

In the matter of models, Mr. Wenderoth was very reasonable, and we will, I am sure, get together on a specification that will give more satisfactory results than were obtainable in the past. He still insists, however, on all models of ornament being made in Washington under his supervision, but it is very probable that, in the future, only units of ornament will be sent to manufacturer, and all plain and moulded surfaces will be made into models at manufacturer's shop.

Before preparing the text of a suggested specification, it was thought wise to lay out a plan, so to speak, upon which to build said specification, and I am enclosing herewith an outline which pretends to cover the ground fairly well. Please look this over, and if you have any suggestions to make, let them come along as early as possible. Mr. Wenderoth has agreed, tentatively, to most of the items contained on enclosed memorandum, although Mr. Olsen and I have an engagement with Mr. Wenderoth and his expert in Washington for next Wednesday to take up each one of the propositions item by item. In view of this, I hope to have in hand by next Tuesday, any suggestions you may desire to make.

Yours truly,

Assistant Secretary.

F. WAGNER, President
CHICAGO
E. V. ESKESEN, Treasurer
SINGER BUILDING, N. Y. CITY.

WALTER GEER, 1st Vice-President
NEW YORK.

W. D. GATES, Secretary
PEOPLES GAS BUILDING, CHICAGO.

W. E. DENNISON, 2d Vice-President
SAN FRANCISCO

H. J. LUCAS, Assistant Secretary
METROPOLITAN BUILDING, N. Y. CITY

ROOMS 9028, 9029

TELEPHONE
1021 GRAMERCY

NATIONAL TERRA COTTA SOCIETY

METROPOLITAN BUILDING

NEW YORK CITY

SEND ALL
OFFICIAL COMMUNICATIONS
TO NEW YORK OFFICE.

August 20, 1914

New York Architectural Terra Cotta Co.

401 Vernon Avenue,

Long Island City, N.Y.

Dear Sir:-

This office has received from the Treasury Department at Washington, communications as per copies attached hereto. This is an important matter and it is very desirable that we now attempt to standardize the processes referred to by the Supervising Architect.

We therefore write to ask that your Company, if it has received similar letters, refrain from replying definitely thereto (except by way of acknowledgement) until we can whip into shape rules of procedure which would be mutually agreeable to all manufacturers and satisfactory to all concerned,

The Eastern Division will make a definite recommendation in this matter with the next few days, and same will be submitted to the larger Companies in other Divisions for general approval before transmission to Washington.

Yours truly


Assistant Secretary

HJL/AD

F. WAGNER, President
CHICAGO
E. V. ESKES, Treasurer
BUNDESBUILDING, N. Y. CITY.

THOMAS F. ARMSTRONG, 1st Vice President
PHILADELPHIA
W. D. GATES, Secretary
PEOPLE'S GAS BUILDING, CHICAGO

W. E. DENNISON, 2d Vice President
SAN FRANCISCO
M. J. LUCAS, Assistant Secretary
METROPOLITAN BUILDING, N. Y. CITY.

NATIONAL TERRA COTTA SOCIETY

TELEPHONE
1921 GRAMERCY

METROPOLITAN BUILDING

NEW YORK CITY

ADDRESS
OFFICIAL COMMUNICATIONS
TO NEW YORK OFFICE.

April 13th, 1915.

AVISEE 12222
COLUMBIA UNIVERSITY

TO AGENTS REPRESENTING
TERRA COTTA MANUFACTURERS WHO ARE
MEMBERS OF THE NATIONAL TERRA COTTA SOCIETY.

COPY

Dear Sirs:-

This Society is sending today to Agents representing Terra Cotta Manufacturers who are members of this Society, one copy each of Architectural Terra Cotta, Brochure Series, Volume 1, "The School"; Volume 2, "The Theatre". All agents have previously received "Standard Construction". Like "Standard Construction", these new Booklets are for office use and general information of Agents, and not for distribution.

All publications of the Society are distributed by and in the name of the Society from its Executive Offices. Agents who are sure that certain Architects, Owners or others can and will make good and valuable use of this literature, should send names, with facts, to the Company they represent. Booklets will be sent to the parties if the facts justify and if the Companies endorse the application and send same to the Society; provided, of course, that copies have not previously been presented to same parties. These books are costly and should be distributed only where they are likely to make terra cotta business.

Yours truly,



Assistant Secretary.

F. WAGNER, PRESIDENT
CHICAGO
F. V. ECKHART, TREASURER
SINGER BUILDING, N. Y. CITY

THOMAS F. ARMSTRONG, 1ST VICE PRESIDENT
PHILADELPHIA

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H. J. LUCAS, SECRETARY
CHICAGO

NATIONAL TERRA COTTA SOCIETY

ROOMS 9028-9039
—
TELEPHONE
1921 GRAMERCY

METROPOLITAN BUILDING
NEW YORK CITY

SEND ALL
OFFICIAL COMMUNICATIONS
TO NEW YORK OFFICE

April 10th, 1916.

To the Members of the
National Terra Cotta Society

Dear Sirs:-

Arrive 1000 by
COLUMBIA UNIVERSITY

The committee appointed at the December meeting of the Society to prepare a revision of the uniform contract requests the members to furnish the committee with suggestions for changes in the present form. It is particularly desired that they shall point out any provisions in the existing form that are in any way unsatisfactory.

At the December meeting there were some suggestions made to the effect that a simple form of acceptance might be used for orders small in amount. The committee would like to have the views of the members on this point and asks that those who are in favor of an acceptance shall submit a draft of a proposed form.

The committee would like to have a reply from each member on the following specific points in connection with the form of estimate blank adopted some time ago by the Society:

- 1st: Are you using this standard form?
- 2nd: If not, are you willing to do so?
- 3rd: What changes, if any, do you suggest in the present form?
- 4th: Do you think it would be a good thing to print on the blank substantially the following: "Standard form of estimate blank adopted by the National Terra Cotta Society."

The committee would consider it a favor if each member would supply a copy of their estimate form as now used.

The committee would also appreciate an answer to the following: Are you generally using the present standard form of contract and if you are not using it please furnish a copy of what you usually use?

The committee has received form of agreement and estimate blank from Gladding, McBean & Company, form of agreement from H. Clark & Sons, estimate blank from American Terra Cotta Company and contract and estimate blank from Northern Clay Company, accompanied by suggested amendment to article #5. No communication on this subject has been received from any other member.

It is requested that reply to this letter be sent to the undersigned at #1170 Broadway, New York, by May 15th, 1916.

Yours truly,

William H. Lueder, Chairman,

Contract Committee.

SOCIETY OF CONSTRUCTORS OF FEDERAL BUILDINGS
Office of the President,
New Orleans, La.

November 6th, 1914.

Northwestern Terra Cotta Co.,
2525 Clybourn Avenue,
Chicago, Ill.

Sirs:-

RECEIVED NOV 11 1914
FEDERAL BUILDINGS
NEW ORLEANS, LA.

The Society of Constructors of Federal Buildings, an organization composed principally of the field employes of the U. S. Treasury Department, Supervising Architect's Office, will meet in convention at Washington on the 4-5-6 of January, 1915, and it is intended to devote a day to having manufacturers of materials used in the construction of U. S. Public Buildings meet with us and give us a talk regarding the manufacture or preparation for use of these various materials. This talk or address could cover such points as what is considered perfect materials in the various branches, what is considered defects, difficulty of producing absolutely perfect materials, etc., In fact, give us a heart to heart talk from the Manufacturers or producers standpoint.

It is believed that such a meeting will be very beneficial to all concerned and as you supply material to a large number of U. S. Public Buildings I am asking if you could have a representative meet with us at our convention and give us a talk as outlined above.

In case this meets with your approval I will advise you as to the day set for this purpose.

Yours very truly,

(Signed) H. C. Richey,
President, S. C. F. B.

①⑧

November 9, 1914.

Proposed Meeting January 4th, to
January 6th, 1915.

H. G. Richey, President,
Society of Constructors of Federal Buildings,
New Orleans, La.

DAVEY LIBRARY
COLUMBIA UNIVERSITY

Dear Sir:-

We note contents of your favor of the 6th.

We shall take this matter up with the National Terra Cotta Society and if this Company should find it difficult to have a representative at your meeting, we will arrange to have one of the Eastern Terra Cotta Companies' men render the desired address. We think this is a very good idea which shall have our full cooperation.

Yours very truly,

THE NORTHWESTERN TERRA COTTA COMPANY
F. Wagner, Vice Pres.

GLOSSARY

anchor:

a piece or connected pieces of metal for securing together more or less permanently two or more pieces of material or members of construction; used generally in connection with masonry. It may be comparatively small and simple, as a cramp to connect two stones in a wall, or a large and important member, as a tie rod passing through the opposite walls of a building and secured on the outside by means of plates and nuts (Sturgis 1902)

a metal tie or plate used to fasten together timbers or masonry (Getty 1990)

a specially shaped metal or ceramic pin to hold ceramic fiber blankets or panels in place to form furnace linings. Other unshaped linings (or refractory concrete) are also anchored to the furnace by notched or shaped rods and bars (Dodd & Murfin 1994)

an L-shaped supporting device used to mount glass, masonry, concrete and other hollow blocks, panels or units to a wall or other surface (McColm 1994)

For ashlar or courses balanced on the wall, shall be $\frac{1}{4}$ " x $\frac{1}{4}$ ", $\frac{1}{8}$ " x $\frac{5}{8}$ " or No. 6 galvanized wire; for projecting courses not balanced on the wall, shall not be less than $\frac{5}{8}$ " round or square bars of equal cross section; (NTCS 1927 Specifications)

Anchoring materials are designed and selected at the same time as the mortar. Nonferrous materials must be used. Stainless steel is durable and does not rust, but it is expensive. More economical materials are hot-dip galvanized steel and epoxy-coated steel. Zinc plated steel is also acceptable if baked to avoid hydrogen embrittlement. Sizes and shapes of anchors depend on the original design, the work to be installed and the state of the back-up masonry. Existing anchors or hangers should never be reused. (Berryman 1984)

Where for any reason anchor or tie rods are necessary in free-standing work, they should be of bronze, stainless steel, or other non-corroding metal; For projecting work, such as gargoyles, cornices, etc, or for exposed situations, such as the rail of a balustrade, only bronze, stainless steel, electrolytically (cadmium plated) steel, everdur, or other assuredly non-corroding metals should be employed. Galvanizing or dipping in asphaltic paints are of little value. (Lockhardt NTCS 1931)

Davis System: The face of the structural concrete is cast to form a series of recessed steps, with anchor rods projecting. As the terra cotta is set, the mason slushes it full with what is really a concrete mortar, which keys into the recesses already provided, and is further anchored to the structure by means of tie rods engaging those previously left projecting from the concrete. (Lockhardt NTCS 1931)

The terra cotta blocks were anchored to the supporting wall with metal members, usually iron. These anchors had to be protected against corrosion, and this usually was done by

coating them with cement or asphalt. In pieces which were not backfilled and this subject to water penetration, bronze anchor rods were recommended because of their resistance to corrosion. (Mack 1983)

Flat or simply profiled blocks of terra cotta were usually anchored to the masonry backing with “z”-shaped anchor straps. Theoretically, each block was anchored individually with a strap anchor fitted into a recessed slot at the top, so that it would not interfere with the joint. (Meadows 1986)

Stainless steel, for example, has generally replaced galvanized iron in anchors and rods to prevent corrosion damage. (Meadows 1986)

Where protection against corrosion is attempted, it may be an asphaltic dip, a copper, galvanized or udyllite coating or a relatively non-corrosive metal like copper that is used. It is our belief that a rust resisting medium should be used for all anchors, bolts, etc. Where in present practices blocks are left unfilled a thin protection of mortar that may or may not adhere to an anchor is questionable protection. We believe in the necessity of a protected anchor and a protection that is a certain one. For this purpose there are several materials or alloys available that show high rust resistance. (Johnston 1926)

Anchoring was provided for the terra cotta and ceramic veneer. For wall blocks, a strap anchor was sufficient, but for other sections more complicated systems were devised. A great variety of connectors was used to suspend and attach complicated terra cotta elements to masonry, steel or concrete back-up. Depending on the structural system and the back-up selected, sufficient tolerance was left in the connectors to allow for installation. (Prudon 1978)

For regular wall anchors, cracking may be found mostly to extend over the full height of the block; when corrosion is advanced sufficiently, it may even extend into the adjoining blocks or mortar joints. (Prudon 1978)

Backfilling:

Once set, the terra cotta blocks frequently were backfilled. This filling was intended to knit the block to the main body of the building, not to actually support the blocks...There was little agreement as to the best material for filling the blocks. (Mack 1983)

In fact, one portion of this organization believe in complete filling, while there seems to be another group who are doubtful about its value.

Advantages: (Johnston 1926)

1. It makes rigid a construction
2. It offers some protection to corrosion of anchors
3. By the mechanical bond it may tend to hold pieces in place, perhaps even when cracked
4. It tends to carry the terra cotta block weight immediately to the back wall (thus minimizing the load on individual blocks.)

5. It may reduce the accumulation of large water pockets
6. It acts as a sound absorbent, getting away from the resonating box effect of unfilled sections.
7. It furnishes a tie system in many conditions, where the metallic tie anchor system is hard to place.
8. It tends toward a complete unit construction which possibly is an advantage in localities subject to heavy vibrations or earthquake shocks.
9. By some, it is claimed that filling strengthens the terra cotta block

Disadvantages:

1. Concrete is known to expand under certain conditions with age, especially if it becomes water soaked and such expansion may rupture the terra cotta.
2. The absorption of water and subsequent freezing may cause damage.
3. A system of filled blocks keyed tightly and quite individually to the backing wall will not permit full play to the blocks in the adjustment necessary for temperature changes and the deflections from various causes.
4. The thermal expansion of concrete is different and greater than that of terra cotta, and it is in general a better conductor of heat, besides, the terra cotta would be subjected directly to the sun's rays, while the filling is protected, so that possibly the combination may set up differential strains that would prove undesirable, especially in some climates.
5. The increased rigidity of filled construction may throw heavy stresses on the terra cotta in buildings subjected to heavy wind pressure.
6. The dead weight of the fill, if not properly keyed and supported by the backing wall, may add just so much more load to the lower block courses and thus cause crushing of the terra cotta.
7. Filling adds extra weight to the structure, which in modern buildings means heavier structural sections with resultant increased cost, to which of course must be added the extra cost of the fill itself.

When unfilled, the flexural and torsional resistances of the anchor system will permit the desired movement. (Johnston 1926)

If the blocks remain unfilled as a whole, we must be sure that the recommended construction is otherwise protected against corrosion. The parts that would need protection are the anchors, anchor bolts, shelf angles, and structural supports for cornices, etc. (Johnston 1926)

Blocks:

Because it was not considered economical to use blocks larger than 27" x 24" x 36", the blocks themselves were designed to be fairly small. Recommended sizes ranged from 4" to 14" high, 12" to 24" wide, and 4" to 18" deep. (Mack 1983)

Most terra cotta block was approximately 4" deep, with a wall thickness of about 1" to 1 ¼" ...Regular, narrow face area of basic blocks was usually between 2 and 2 ½ square feet.

The blocks were made with internal webbing for strength, but were open at the back, permitting them to be keyed to the backup masonry. (Meadows 1986)

Although terra cotta can be made solid, making it hollow requires less raw material, the pieces dry quicker, can be burned quicker and, of course, are less expensive. Then the weight of hollow terra cotta, which is much less per cubic foot, also effects saving in freight, cartage and cost of handling at the building. The hollow blocks are generally made from 18" to 2' long, from 6" to 12" deep and of a height determined by the character of the work, although pieces have been made from 6 to 8 cubic feet in volume and weighing one-quarter of a ton. The outer shell is made 1 ½" thick and the webs and partitions about 1" thick. The partitions should have numerous holes in them for convenience in handling and to afford a clinch for the mortar and brickwork used for the filling and backing, and they should be so arranged that the open spaces shall not exceed 6". In fact, all the work should be divided into as short lengths as practicable. Short lengths are more easily handled and are less liable to break and warp than long ones, although, contrary to the general belief, small pieces are more expensive to manufacture than large pieces... (Warren 1905)

Provisions for anchoring systems were also made in the block. Small holes at the side allowed for the insertion of dowels, and a recessed slot at the top made it possible to insert a strap anchor. The recessing prevented these anchors from blocking the mortar joint and made repointing possible. (Prudon 1978)

Clips:

Shall be 3/8" x 2" (NTCS 1927 Specifications)

When facing reinforced concrete...Metal keyways may be lightly attached to the forms at suitable intervals, so that when the forms are stripped the keyways are anchored in the concrete. Clips which are shaped to fit the keyway have a hole in them through which the anchor rods may be passes. As the clips can be placed in the vertical keyways at any point the system is very flexible. (Lockhardt 1931)

The iron clip shown in fig. 5 gives the maximum liberty of spacing of supporting member and makes an effective clamp to counteract any twisting of angles or bars. (Tindall 1989)

Clamps:

All blocks not solidly built into the walls should be anchored with galvanized iron clamps, the same as for stonework, and, as a rule, all projecting members over 6" in height should be anchored in this way. (Fitzsimmons 1984)

Columns:

The maximum distance between columns being about 9', the necessary support is supplied by two 5" channels placed back to back and bolted together at intervals of 4' with just enough room to receive the ¾" hangers: which passing between them, take the place of separators. (Cusack 1896)

Cornice:

Projecting cornice units were suspended from anchorage systems by steel J-bolts, which held horizontal bars threaded through holes formed in the webs of the terra cotta block. (Hunderman 52)

The top of the cornice is protected by a copper roof with regletted copper flashing. Scuppers extending through the wall permit water to drain back from the cornice onto the roof of the building. The cornice is supported by brackets at each exterior wall column. Horizontal I-beams span between these brackets, along the entire length of the cornice. The uppermost terra cotta course is also supported against overturning by a horizontally oriented steel hanger... This hanger, which is tied to a horizontal rod, projected through the webs of the terra cotta unit. The weight of this uppermost course of terra cotta is supported by a continuous angle, which is in turn supported by a series of steel brackets on the web of the main I-beam in the cornice. The support for the dentils and the course of terra cotta directly above the dentils is provided by a series of steel hangers. These hangers are hooked around the top flange of the I-beams above, and run vertically downward to a horizontal rod inside each of the dentils. (Hunderman 1988)

Two concentric rings of structural steel channels which are tied to steel girt outlookers provide the main support for the cornice. The outlookers, in turn, are cantilevered from the structural steel columns of the building. The interior of the cornice is filled with lightweight masonry material and lacks any ventilation. (Levine 1991)

For larger overhanging horizontal elements, such as major cornices or balconies, different and sometimes elaborate support systems were necessary. Blocks were attached to angles or rods, or suspended from steel members used as outriggers with standard hook and dowel systems. If the system was properly designed, it allowed for some adjustment during installation. Frequently, these sections were backfilled with concrete, more for protecting the anchoring systems from corrosion than for structural reasons. (Levine 1991)

Spandrel panels, soffits, sections of cornices, and lintels were connected by being suspended from a steel member. That is, dowels were placed in the sides of the block. These dowels fitted into a hook suspended from the steel structural member. The hook was fitted into a slot and bolted in the steel, allowing for some adjustment. (Prudon 1978)

With stone cornices it is necessary that the various pieces be of sufficient depth to balance on the wall. With terra cotta cornices, however, this is not necessary or customary, the various pieces being made to build into the wall only 8" or 12" and to be supported by iron work. Generally small steel L's and T's, as shown in Plate I, are used for supporting the projecting members, and where the projection is so great as to overbalance the weight of the masonry on the built-in end, allowing for the weight of snow on the projection, the inner ends of the supports are anchored by rods carried down into the wall until the weight of the masonry above the anchor is ample to counteract the leverage of the projection. Therefore, wherever iron is used for tying the cornice to the walls it is necessary to

determine the method of anchoring before the pieces are molded, as in manufacturing them holes or slots must be made for inserting the beams, rods and anchors. (Warren 1905)

Large cornices or belt courses required extensive anchoring and support systems, especially when the cornices protruded far. Cornices were initially not anchored to the wall but kept in place by the masonry on top. The detailing was similar to stone masonry construction. For larger structures, the cornices and belt courses had steel angles and outriggers attached to structural frames or the masonry to support the large units. Soffits, brackets and dentils could be suspended from these outriggers by standard hook and dowel systems. When the voids of the cornices were not completely back-filled, weep holes would be provided. (Prudon 1978)

Large overhanging elements, such as cornices, belt-courses, or balconies, are very susceptible to damage caused by corrosion of anchoring and support systems. Leaking roofs, flashing, and faulty caulking or pointing are very likely to exist in these locations. Terra cotta units suspended from steel outriggers with anchoring devices may crack and shatter because of corrosion, not just of the anchors but also of the steel outriggers, creating very hazardous conditions. In these cases, the suspended terra cotta units are no longer secured and may be in danger of falling...Window lintels may also be affected in that manner. (Prudon 1978)

Dowels:

For each piece less than 1'8" long, use one dowel ½" shorter than the piece. For each piece 1'8" or longer use two 10" dowels for each running length. (Tindall 1989)

Hangers:

Shall be 5/8" diameter round bars or other shapes of equal cross section area (NTCS 1927 Specifications)

Excepting very short pieces, there should be two hangers for each running length; and for wide soffit courses there should be two rows of hangers to each course. (Tindall 1989)

The ½" hangers and 5/8" dowels are proper for all ordinary work, though for very light sections where space is limited, 3/8" hangers and ½" dowels may be used. (Tindall 1989)

Hooks:

Prior to 1885, terra cotta was 'hung' on the walls as window caps, or other types of surface decoration. In this process the terra cotta blocks were filled with mortar and pressed into place. Hooks which previously had been driven into the wall joints then penetrated the mortar grout. The terra cotta was held in place until the mortar had hardened, at which time the hooks held the blocks in position. Around 1885 it was realized that the pieces could be built into the wall, leading to rapid development in its use. (Mack 1983)

Hooks anchored to the supporting wall passed around a bar running between the end shells of two blocks; in this system, anchor placement was critical, as no adjustments were possible in any direction. (Mack 1983)

A horizontal bar was fastened to the wall anchors, with a separate set of hooks running from the horizontal bar to holes in the tops of the blocks; horizontal adjustment was possible with this system. (Mack 1983)

The horizontal bar was placed in a recess in the supporting wall and was held in place with wires rather than hooks (Mack 1983)

Metal Work:

All steel or iron supporting metal work shall be clean and thoroughly protected with two coats of pure red lead and linseed oil paint, asphaltum applied hot, or other approved protective compound.; metal work of every description, supporting terra cotta, shall be imbedded thoroughly in the masonry backing and when not so imbedded, metal work shall be protected against corrosion by encasing with cement mortar or in cement mortar masonry; When the back of a terra cotta course comes in contact with iron or structural concrete in such a manner as to prevent the encasing of supporting iron from the rear, an opening shall be made in the top to admit of the placing of the encasing mortar as required above. (NTCS 1927 Specifications)

Outriggers:

Outriggers are small, repetitive steel beams cantilevered perpendicular to the wall plane to carry a projecting masonry cornice, balcony, or other decoration. The spacing of these beams is typically matched to the block sizes so that each joint between the terra-cotta units contains an outrigger, while their form is adapted to provide bearing surfaces for the masonry above. Outriggers are typically inverted T's or inverted double angles. The masonry is simply laid up block upon block above the outriggers, while the units below must be hung from the steel. To reduce the amount of hung terra cotta, outriggers are typically placed as low in the architectural volume of the cantilever as is possible. The outrigger system requires one additional structural element –the outriggers themselves. (Friedman 1995)

The most complex system is the bracketed-beam system, where large beams parallel to and outboard of the base façade plane are carried on brackets from the spandrel columns. Two elements of additional structure are required, the brackets and the exterior beams themselves. The large size and large forces contained within these members makes their design entirely part of the structural frame of the building rather than the façade. Because the exterior beams do not provide direct support, the steel-hanger techniques described above for outrigger soffits are used in the bracket-beam system to support all of the terra cotta. Those units that rest on other units are still ultimately supported by units hung from the steel. (Friedman 1995)

Pins:

Shall be ½" diameter round bars (NTCS 1927 specs)

The installation of pins through the face of the units should be avoided because this is difficult to conceal. Where pinning through the face is required to stabilize a unit, the pin location may be covered with a small cementitious patch, painted to match the color of the adjacent terra cotta. (Slaton 1996)

Rods:

Continuous rods on concrete wall faces to which terra cotta ashlar is clipped, shall be 5/8" diameter round bars which shall be secured to the masonry with ½" diameter round anchors placed not more than 2'0" on centers. (NTCS 1927 specs)

Otherwise, if wire anchors embedded in the concrete are not used, rods are left projecting from the face of the wall at suitable intervals, and after the forms have been removed, the projecting ends are turned up to engage and hold horizontal rods over which the anchor-irons are slipped. (Lockhardt 1931)

Angle irons are frequently used in lintel construction. A short metal rod is placed in one of the holes shown in the terra cotta pieces and in a corresponding aperture in the adjacent piece. An iron anchor engages with this rod between the two pieces and the rebates are slushed with mortar to protect the iron from rust. The anchoring rod is engaged with the structural steel. (Mack 1983)

Soffits:

The soffit blocks are made in lengths of 1'10" with two hangers placed 3" from the ends. The ¾" rod having been inserted in the hole, which passes longitudinally through each piece, the chambers are then filled with concrete before being set in position. (Cusack 1898)

Straps:

Shall be 3/8" x 2" (NTCS 1927 Specifications)

Steel straps were set into slots at the back of each unit for horizontal support and tied to the anchorage system of the wall behind. (Hunderman 1988)

Shelf Angles:

"Shelf Supports": In concrete or steel frame buildings, the veneer or facing material should be fully and continuously supported, at each floor level on shelf supports, of adequate strength and stiffness, rigidly constructed to the structural frame. Steel shelf angles or supports, in all cases, should be located in mortar joints. The strength of the terra cotta should not be necessarily reduced by cutting the webs to receive the steel. (NTCS 1927)

When used as cladding, the units were typically supported by steel shelf angles at floor levels, above wall openings, and at projections such as cornices. (Hunderman 1988)

When the blocks were used as a veneer with anchors rather than backfill, shelf angles were required at regular intervals to prevent crushing of the blocks. Blocks resting on this angle then either were wired directly to it or were anchored to the wall to prevent movement away from the wall. (Mack 1983)

Some shelf angles were missing, others had corroded away all of them stopped 2 to 3 feet short of the wall corners. The uneven vertical support, especially at the corners, caused extensive vertical cracking free from shear failure between supported and unsupported terra cotta... Rust scale expansion at the tow of the shelf angle caused cracking and spalling of the terra cotta blocks just above and below the shelf angle. (Searls 1991)

A steel beam bolted through its flanges to shelf angle supports on a column is not as fully fixed as one riveted to the column through its web. (Johnston 1926)

Study of your past details of shelf angles indicated that preference was given to the angle placed with the attaching leg up. Further, there is the apparently universal acceptance of a two inch clearance between the face of the terra cotta and the outer edge of the shelf angle. Such a construction necessitates first, the use of a three inch leg angle; secondly it gives only two inches maximum bearing of the shelf block on the angle; thirdly it means that wherever an anchor bolt goes through the shelf angle a piece of the terra cotta block has to be cut out in erection of the block to clear the bolt and nut; fourthly, with the angle placed with attaching leg up and bearing leg down, advantage is taken of a slightly stronger construction due to the 'thrust' reaction furnished by the wall, at the heel of the angle... a two inch bearing is too small...in reality a two inch bearing will seldom be secured on account of the warping of the block in drying and burning. This latter makes it necessary to set the block out to clear the angle edge and this reduces the bearing by the amount the block it set out. Secondly, this construction necessitates cutting the shelf block wherever an anchor bolt occurs. Field cutting on general principles is undesirable. Such cutting will never be done as carefully as shop cutting, so that there is great liability of damage to the block, and in this instance, the damage is done to the shelf block which is the one under greatest superimposed load. (Johnston 1926)

It was decided first that the back of the block should be set 1 ¼" from the backing wall, so as to eliminate as far as possible field cutting with its extra hazards and costs... In order to make sure that any excess projection of the bolt would not cause injury to a basic block, if cutting was necessary, we turned the shelf angle over, attaching leg downward so that if interference did occur, it would necessitate cutting only on the blocks immediately below the shelf angle and thus the cutting of blocks carrying minimum load. It is true that by doing this we may lose a slight advantage in strength, through loss of the wall thrust at the angle heel... a standard shelf angle of this type is generally overstrong for the loads coming on it; secondly, with the shelf angle placed as shown, a wider surface is available for block bearing; thirdly, the position of the block load is so close to the wall face that it is doubtful

if there is any great difference in the kind of stress coming on the anchor bolt...it was considered to better to use a 3 ½" leg and secure the advantages of greater bearing for the block. (Johnston 1926)

When a proper shelf angle has been used, corrosion may develop at the front of the angle closest to the exterior surface. The corrosion will cause the terra cotta to crack and spall along the front of the angle. Where the cladding was continued over the support steel, as was frequently the case in early terra cotta construction, the corrosion will cause horizontal cracking in the terra cotta. This horizontal cracking may be detected in its earlier stages by a slight bulging of the terra cotta. (Prudon 1978)

Expansion Joints:

Proper provision should be made for expansion joints, at shelf supports, over column caps, etc., to prevent the development of disruptive stresses caused by deflection, wind pressure, temperature changes, settlement, and like forces (NTCS 1927)

Expansion Joints may sometimes now be installed to decrease the excessive façade stresses characteristic of many early high-rise buildings. (Meadows 1986)

Parapets had cracked due to thermal expansion and an absence of expansion joints. (Searls 1991)

In the vertical height of the building we have the same necessity for allowing for thermal changes, for shrinkage in concrete, for flectural movements...This discussion shows the necessity of preventing the accumulation of heavy strains on the terra cotta facing from such causes. The only practical way to accomplish this is to incorporate what may be called open joints –open only in the sense however, that they must be joints designed to permit the free shortening of the structure from such causes as have been discussed here. Consideration of the character of deflections occurring in a building suggests that probably the best location for such joints is in the vicinity of the floor levels. As this is where the shelf angles for supporting the terra cotta are most conveniently placed, such joints then must be considered as part of the standard shelf angle detail. Another reason for placing the joints as such a location is that, due to the present necessity of using a plastic material for these joints, the joint location must be where a minimum load comes upon the mastic. This last requirement necessitates the plastic joint being placed just below the shelf angle. (Johnston 1926)

They must be wide enough to permit of good, thorough caulking with the mastic and such caulking probably can best be done with a pressure gun. The also should be wide enough to insure a depth of plastic material that can squeeze and draw so that especially on drawing, as the joint is opened, the plastic will not divide and leave a crack for water to enter. Considering all things, we believe that 3/8" width of joint is the most practical. (Johnston 1926)

Window Sills and Lintels:

An arch lintel 14" deep and 16" reveal would be quite safe over an opening of 5', without any auxiliary support. Beyond that width, instead of 12", we would use two 6" I-beams, placed so as to carry the brickwork above and relieve the lintels below. (Cusack 1898)

Window sills and lintels are generally made in pieces from 18" to 2' long. Jamb blocks are usually 1'6" high or thereabout and should be designed to bond in with the brick work. (Warren 1905)

BIBLIOGRAPHY

Aderman, Ella Webster. "Architectural Terra Cotta: On-Site Evaluation and Testing." Masters, University of Pennsylvania, 1986.

The American Terracotta Index. Edited by Statler Gilfillen. Palos Park: Prairie School Press, 1974.

Architects, American Institute of. *The Standard Documents of the American Institute of Architects*. Washington, DC: The American Institute of Architects, 1911.

"Architectural Terra Cotta." *Brick and Clay Record*, no. 33: 31-35.

"Architectural Terra Cotta." *Brick and Clay Record*, no. 32: 135-36.

"Architectural Terra Cotta Investigations." *NBS Technical News Building* 8, no. June (1925): 3-4.

Atkinson, George. "Terra Cotta Rehab." *Building* 44, no. 241: 43.

Barret, M. "Is the Filling of Architectural Terra Cotta with Concrete Necessary or Desirable?" *ACS Journal*: 79-82.

Barton, A. Daniel, Jr. "O. W. Ketcham Terra Cotta: Reflections on an Industry in Chaos after World War Two." *APT Bulletin* 32, no. 4 (2001): 11-16.

Becher, P.F. "Advances in Architectural Ceramics." *MRS Symposium Series* 78.

Bell, Ingress E. "The Revived Use of Terra Cotta in Architecture." *The Art Journal*, no. 50: 119-20.

Berryman, Nancy D., and Susan M. Tindall. *Terra Cotta*. Chicago: Landmarks Preservation Council of Illinois, 1984.

Boston Fire 1871 [cited 1/30/ 2003]. Available from www.fire-police-ems.com/books/bg3730.htm.

Boston Valley Terra Cotta, Company. Architectural Terra Cotta- Standard Construction. Boston Valley Terra Cotta Company, Orchard Park, New York, 1997.

Bourry, Emile, and A. B. Searle. *A Treatise on Structural Ceramic Industries: A Complete Manual for Pottery, Tile, and Brick Manufacturers*. London: Scott Greenwood and Son, 1919.

Brantley, L. Reed, and Ruth T. Brantley. *Building Materials Technology*. New York: McGraw Hill, 1996.

Burns, R. M., and W. W. Bradley. *Protective Coating for Metals*. Edited by F. Marshall Beringer. 3rd ed, *American Chemical Society Monograph Series*. New York: Reinhold Publishing Corporation, 1967.

Casodia, R. and Fabri, B. The Deterioration of Terra Cotta: The Case of Casa Valenti in Faenza. Science, Technology, European Cultural Heritage, Bologna, Italy,

Ceccacci, Susan McDaniel. "Architectural Terra Cotta in the United States before 1870." Master of Art, Boston University, 1991.

Chicago Fire 1871 [cited 1/29/ 2003]. Available from www.chicagohs.org/fire/ruin/index/html.

Clay Masonry Products Terra Cotta (Ceramic Veneer) The Northwest Masonry Guide, [cited October 23 2002]. Available from www.masonryinstitute.com/guide/part2/prod_a2-p1-2.html.

Committee, Chicago Department of Buildings. "Setting Terra Cotta." *The American Architect/The Architectural Review* 123, no. 2419 (1923): 435-536.

Comparative Recapitulation Sheet: Reports of Orders. National Terra Cotta Society, New York, 1913.

- Condit, Carl W. *American Building Art: The Nineteenth Century*. New York: Oxford University Press, 1960.
- Congress, New York Building. "Standard Specification for the Manufacture and Furnishing of Terra Cotta." *American Architecture and Building News* 135, no. 2570: 768-70.
- . "Standard Specifications for Setting of Terra Cotta." *American Architecture and Building News* 139, no. 2571: 837-39.
- Cotta, Friends of Terra. "Technical Notes." *Friends of Terra Cotta Newsletter* 3, no. 2 Summer: 12-13.
- Croly, Herbert D. "The Proper Use of Terra Cotta." *Architectural Record*: 73-81.
- Cusack, Thomas. "Architectural Terra Cotta." *The Brickbuilder* 5 (1896): 6-8, 29-32, 51-53.
- . "Architectural Terra Cotta." *The Brickbuilder* 7, no. 1 (1898): 7-8.
- . "Architectural Terra Cotta." *The Brickbuilder* 7, no. 3 (1898): 55-57.
- . "Terra Cotta and Steel." *The Brickbuilder*, no. 1: 226-29.
- Darling, Sharon S. "The Northwestern Terra Cotta Works." *Chicago Ceramics and Glass*: 168-69.
- Durham, Diana. "Terra Cotta Renovation at the Natural History Museum." *Glazed Expressions* 12, no. Summer: 10-11.
- Eskesen, E.V. "The Investigation of Terra Cotta Work at the Bureau of Standards." *ACS Journal* 4 (1924): 158-68.
- . "Presidential Address for the Thirty-Fourth Annual Meeting of the American Ceramic Society." *Journal of the American Ceramic Society* 15 (1932): 81.

———. "Watertight Terra Cotta Construction." *ACS Journal* 13 (1934): 154-62.

Fellowship, The National Terra Cotta Society. Summary of the Printed Reports 1-8 and the Technical Work of the Society. National Bureau of Standards, Washington DC, 1922.

Ferriday, Virginia Guest. *Last of the Handmade Buildings: Glazed Terra Cotta in Downtown Portland*. Portland, OR: Mark Publishing Co., 1984.

Fidler, John. "The Conservation of Architectural Terra Cotta and Faience." *Friends of Terra Cotta Newsletter* 3, no. 1 (1983): 12-16.

———. "Repair of Architectural Terra Cotta and Faience-Part I." *SPAB News*, no. 4: 51-53.

———. "Repairing Terra Cotta- Part II." *SPAB News*, no. 5: 1.

Fitzsimmons, H.L. "Terra Cotta in Building Construction." *The Architect and The Engineer*: 96-99.

Friedman, Donald. *Historical Building Construction: Design, Materials and Technology*. New York: W. W. Norton, 1995.

Fus, Michael. "Architectural Terra Cotta: Standards, Specifications, and Testing." Master of Science, Art Institute of Chicago, 1997.

Geer, Walter. *The Story of Terra Cotta*. New York,: T. A. Wright, 1920.

———. *Terra-Cotta in Architecture*. 3d ed. New York,: Gazlay bros., 1891.

Harris, Cyril M., ed. *Dictionary of Architecture and Construction*. 3rd ed. New York: McGraw-Hill, 2000.

Hedges, Ernest S. *Protective Films on Metals*. Edited by E. Howard Tripp. 2nd ed. Vol. 5, *A Series of Monographs on Applied Chemistry*. New York: D. Van Nostrand Company, Inc., 1937.

- Heubach, A.R. "How Architectural Terra Cotta Is Made: Being a General Treatise of the Subject with Methods of Manufacture, Machinery in Use, and a Classification of the Clays." *Brick and Clay Record* 43: 904-07.
- Hodson, C. N. "Architectural Terra Cotta and Faience." *Ceramic Society Transactions* 36: 45-50.
- Howe, Samuel. "Terra Cotta as a Building Material." *American Architecture and Building News* 110: 177-81, 93-91, 201-07, 57-61.
- Hunderman, Harry, and Deborah Slaton. "Final Touch: Cornice Detail." *APT Bulletin* XX, no. 1 (1988): 64.
- Inland Architect and Builder* 7, no. 11 (1886): 97
- Johnston, Robert Smith. *Principles of Terra Cotta Construction*. National Terra Cotta Society, New York, 1926.
- Kelly, Stephen J. and Jerry G. Stockbridge. "The Railway Exchange Building: A Terra Cotta Renovation." *APT Bulletin* XX, no. 3: 15-22. ~
- Ketcham, O.W. *The Story of a House*. Philadelphia: Edward Stern and Co., 1899.
- Kingrey, W. D., and Pamela Vendever. *Ceramics Masterpieces: Art, Structure, and Technology*. New York: Free Press, 1986.
- Kraemer, T. "The Setting of Terra Cotta and Its Inspection by Architects." *American Architecture and Building News* 131, no. 3519: 551-57.
- Kurutz, Gary F. *Architectural Terra Cotta of Gladding, Mcbean*. Sausalito: Wingate Press, 1989.
- Levine, Jeffery S. "Stabilization and Repair of a Historic Terra Cotta Cornice." *Preservation Tech Notes: Masonry*, no. 2 (1991).
- Lockhardt, William. "Architectural Terra Cotta." *General Building Contractor* (1931).

- Loring, Sanford E., and William Le Baron Jenney. *Principles and Practice of Architecture*. Chicago: Cobb, Pritchard, & Co., 1869.
- Lucas, Harry J. New York Architectural Terra Cotta Company Collection. Columbia University Avery Library, New York.
- . New York Architectural Terra Cotta Company Collection. Columbia University Avery Library, New York.
- . New York Architectural Terra Cotta Company Collection. Columbia University Avery Library, New York.
- Mack, Robert C. *The Cleaning and Waterproof Coating of Masonry Buildings, Preservation Briefs*. Washington, DC: United States Government Printing Office, 1979.
- . "The Manufacture and Use of Architectural Terra Cotta in the United States." In *The Technology of Historic American Buildings: Studies of the Materials, Processes, and the Mechanisms of Building Construction*, edited by Edward Jandl. Washington, DC: Foundation for Preservation Technology, 1983.
- McIntyre, W.A. *Investigations into the Durability of Architectural Terra Cotta and Faience. Building Research Station Special Report, No. 12*. London: Building Research Station, 1929.
- Meadows, Robert E. *Historic Building Facades: A Manual for Inspection and Rehabilitation*. New York: New York Landmarks Conservancy, 1986.
- "Modern Brick Builder's Manual: A Handy Reference for Architects, Engineers, Mason Builders, Dealers." *Brick and Clay Record*.
- Murtagh, William. "The Philadelphia Row House." *Journal of the Society of Architectural Historians* XVI, no. 4 (1957): 8-13.
- "Philadelphia." *The Brickbuilder* 4, no. 9 (1895): 199.

- Plusch, H.A. "Some Causes of the So-Called Disintegration of Terra Cotta, Brick, and Allied Ceramic Materials." *The Chemist* 1: 65.
- Porter, Glenn. *The Rise of Big Business: 1860-1920*. 2nd ed. Arlington Heights, Illinois: Harlan Davidson, Inc., 1992.
- Powell, William H. New York Architectural Terra Cotta Company Collection. Columbia University Avery Library, New York.
- Prudon, Theodore H. M. "Architectural Terra Cotta and Ceramic Veneer in the United States Prior to World War II: A History of Its Development and Analysis of Its Deterioration Problems and Possible Repair Methodologies." PhD Dissertation, Columbia University, 1981.
- . "Architectural Terra Cotta: Analyzing the Deterioration Problems and Restoration Approaches." *Technology and Conservation* 3, no. Autumn 3 (1978): 30-38.
- Putnam, Edward. "Architectural Terra Cotta: Its Physical and Structural Properties." *The Brickbuilder* (1911): 29-33.
- Richey, H.G. New York Architectural Terra Cotta Collection. Columbia University Avery Library, New York.
- Ries, Heinrich. *Building Stones and Clay Products: A Handbook for Architects*. New York: John Wiley and Sons, 1912.
- Rosen, Harold J. *Principles of Specification Writing*. New York: Reinhold Publishing Corporation, 1967.
- Ruskin, John. *The Seven Lamps of Architecture*. New York: Dover Publications, 1880, 1989.
- San Francisco Fire 1906* [cited 1/30 2003]. Available from americahurrah.com/sanfrancisco/municipalreports/1906/index.htm.

Searls, C.L., and S.E. Thomasen. "Repair of the Terra Cotta Facade of Atlanta City Hall." In *Structural Repair and Maintenance of Historical Buildings II: Proceedings of the Second International Conference Held in Seville, Spain*, edited by Brebbia et al. Seville, Spain, 1991.

Segal, Dr. Agnes. *Copper Alloys- Bronzes* AZoM.com, 2002 [cited April 13, 2003]. Available from <http://metals.about.com/gi/dynamic/offsite.htm?site=http%3A%2F%2Fwww.azom.com>.

Slaton, Deborah, and Mark Robert Morden. "Issues in the Salvage and Reuse of Terra Cotta: Two Case Studies." In *Standards for Preservation and Rehabilitation, ASTM Std 1258*, edited by S. J. Kelley, 307-18: American Society for Testing and Materials, 1996.

Sloop, Jessica A. "Repair of Glazed Terra Cotta Surfaces: A Comparative Study of Remedial Coatings for Their Effectiveness of Areas of Glaze Loss in Temperate Maritime Weathering Conditions." Masters, University of Pennsylvania, 1996.

Society, National Terra Cotta. *Architectural Terra Cotta: Standard Construction*. New York: National Terra Cotta Society, 1914.

———. "A Campaign for Better Understanding." *Pencil Points* 1, no. 6 (November 1920): 2.

———. *Standard Specification for the Manufacture, Furnishing, and Setting of Terra Cotta*. National Terra Cotta Society, New York, 1923.

———. *Summary and Index of Reports One to Eight Relating to the Technical Work of the National Terra Cotta Society*. The National Terra Cotta Society Fellowship at the National Bureau of Standards, New York, 1918-1922.

———. *Terra Cotta: Standard Construction*. New York: National Terra Cotta Society, 1927.

Stockbridge, Jerry G. "Analysis of in-Service Architectural Terra Cotta." *APT Bulletin* XVIII, no. 4: 41-45.

Stratton, Michael. "The Terra Cotta Industry: Its Distribution, Manufacturing Processes, and Products." *Industrial Archaeology Review* 8, no. 2 (1986): 194-214.

———. *The Terracotta Revival*. London: Victor Gollancz, 1993.

Sturgis, Russel. *A Dictionary of Architecture and Building: Biographical, Historical, and Descriptive*. New York: The MacMillan Co., 1902.

Taylor, James. "The History of Terra Cotta in New York City." *Architectural Record* 2 (1892): 137-48.

Technical Notes on Brick Construction Brick Institute of America, [cited October 23 2002]. Available from www.bia.org/BIA/technotes/t44.htm.

Terra Cotta Specifications. Edited by F.R.S. Yorke. London: Architectural Press, 1935.

Terra Cotta Work: Modelling, Moulding, and Firing. Edited by Paul N. Hasluck. London: Cassell and Company, Ltd., 1905.

Thrall, C.U. "Terra Cotta: Its Character and Construction I-III." *The Brickbuilder*: 10-12.

Tindall, Susan. "How to Prepare Project Specific Terra Cotta Specifications." *APT Bulletin* XX1, no. 1 (1989): 26-36.

———. "Technical Notes." *Friends of Terra Cotta Newsletter* 3, no. 1 (1984): 4.

———. "Terra Cotta Replacement." *APT Bulletin* XX, no. 3 (1988): 12-14.

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